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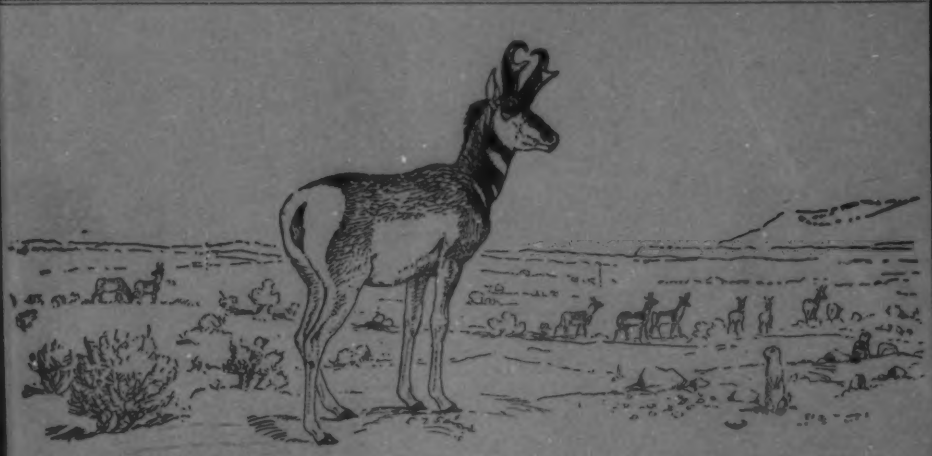

CONTENTS

PAGE

The Supposed Effects of the Color Tone of the Background upon the Coat Color of Mammals ..... *Francis B. Sumner and Harry S. Swarth* 81

Where do Wild Elephants Die? ..... *Gordon Casserly* 113

Removal of the Testicle in a Sika Deer Followed by Deformity of the Antler on the Opposite Side ..... *Charles B. Penrose* 116

Two New Murine Rodents from Kurile Islands, Japan ..... *Nagamichi Kuroda* 118

The Type-specimen of Saurocetus gibbesii Agassiz ..... *Glover M. Allen* 120

Some Further Observations on the Chimpanzee ..... *W. Henry Sheak* 122

General Notes 130

Cinnamon and Albino Opossums Found at Austin, Texas, *W. K. Cuyler*; On the Names of Two Genera of Insectivora, *A. Cabrera*; Sei Whale Specimen Whale Food, *R. C. Murphy*; Another Fossil Caribou from New York State, *A. H. Norton*; The Pygmy or Gaboon Buffalo, *C. R. Aschemeier*; Coues Porcupine in Colorado, *F. W. Müller*; Swimming Red Squirrels, *A. S. Pope*; Death of H. A. P. Smith, *R. W. Tufts*.

Recent Literature 136

Correspondence 144

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THE SUPPOSED EFFECTS OF THE COLOR TONE OF THE BACKGROUND UPON THE COAT COLOR OF MAMMALS

BY FRANCIS B. SUMNER AND HARRY S. SWARTH

[*Plates 6–12*]

The existence of a general correlation between atmospheric humidity and the depth of color of birds, mammals and some other groups of animals has become a commonplace in biological literature. It is plain, however, that the mere existence of such a correlation tells us nothing of the causal agencies at work in the production of the results in question. Thus, in the present instance, it is possible that the effects of humidity upon pigmentation are very indirect. Those who accept the more extreme mendelian-mutation picture of organic evolution will naturally doubt the likelihood of any cumulative effect of environmental conditions upon a race of organisms, whether these conditions are conceived of as acting immediately upon the germ-plasm or indirectly through the cells of the body. Such persons will be disposed to attribute the undoubted correlation just mentioned to the survival of variations (mutations) which are purely random in origin, so far as the environment is concerned. As in all cases of natural selection, the basis of survival must be conceived of in terms of adaptation, or utility in the broad sense.

So far as we know, two chief explanations of the marked color differences between desert and coast-dwelling birds and mammals have been suggested which are based upon the supposed utility of these characters. The more obvious of these explanations is the hypothesis that we have to do with the familiar phenomenon of protective colora-

tion. This interpretation of the facts derives support from the undoubted existence of protectively colored animals, belonging to a wide range of natural groups and occupying a great diversity of habitats. Indeed, the applicability of this principle to the ground-dwelling animals of desert regions will perhaps seem self-evident to most persons who have had much experience in observing them. And conversely, the protective value of a darker colored plumage or pelage against a more somber background will seem to be inherently probable. It is scarcely necessary to point out, however, that the fact that these animals are well concealed by their harmonious coloration is of itself no proof that this shade was developed because of its protective value.

Another attempt to explain these color characters on the basis of utility may be founded on the assumption that the differences of pigmentation, while of no value in themselves, are the visible expression of constitutional (physiological) differences which adapt the animals to different climatic conditions. It is these underlying constitutional peculiarities, rather than color *per se*, which may be supposed to furnish the basis for selection. The possibility of such an origin of the pigmental distinction among our various geographic races cannot be denied. Indeed, it has a considerable measure of plausibility, despite the entire lack of direct evidence in its favor.

It is not our object in this paper to discuss the last-named interpretation of the pigmental differences under consideration. No data at hand seem to be decisive between this view and that of the direct effect of environmental conditions, without the influence of selection. Our present concern is with the hypothesis of protective coloration.

The latter hypothesis, as applied to the prevailing hues of desert mammals, has already been discussed by one of us.[1] Various reasons have been given for doubting the supposed dependence of the degree of pigmentation upon the optical properties of the background. While it is unnecessary to repeat all of these arguments here, it is desirable to state briefly the evidence derived from the special field studies which were described in the earlier paper. About fifty skins from mice which were trapped upon a very dark lava-field in the Mojave Desert, were compared with an equal number from a point about fifty miles distant, in a region of pale, non-volcanic rock, but having closely similar climatic conditions. The mean color values for the two series were found to be almost exactly the same.

[1] Sumner: Desert and Lava-Dwelling Mice and the Problem of Protective Coloration in Mammals. Journal of Mammalogy, May, 1921.

Several things must be emphasized in connection with this result. In the first place the species (*Peromyscus crinitus stephensi*) is one which is known to be restricted in habitat to rocky regions. This point was specially tested by trapping upon sandy areas of the desert, immediately surrounding the lava field. *P. crinitus* was not found to stray far from the lava. Thus the vast level tracts of sandy desert doubtless act as fairly effective barriers between the colonies inhabiting the various scattered areas of rock. It is probable that the *Peromyscus* population of this lava field is self-perpetuating, and that it is recruited but slightly from non-volcanic areas. Yet here we find a very pale species of mouse to be present in considerable abundance. This fact certainly lends no support to the assumption of any very rigid selection on the basis of color. A race which has maintained itself in large numbers for probably hundreds of years cannot be conspicuously ill adapted to its environment.

These findings were not in agreement with the statements of several prominent mammalogists who have been disposed to credit areas of lava with a pronounced modifying influence upon the pelage color of rodents. Definite assertions to this effect have been cited in the earlier paper and need not be repeated here.

The general applicability of these earlier negative conclusions of the senior author has been challenged by various correspondents, including some of those who were responsible for the claims which had been called in question. Stress has been laid by these persons upon the fact (fully recognized in the published report) that the lava field in question was of limited extent, and that it was likewise very recent geologically speaking.[2] In any case, it must be conceded that such negative findings as these cannot be offered as conclusive evidence against the accuracy of positive assertions on the part of other naturalists.

It was urged by several critics that the most favorable locality in which to test this problem of alleged lava influence was the neighborhood of San Francisco Mountain in Arizona. Here, we were told, the volcanic area is vastly more extensive, as well as far more ancient,

[2] Mr. N. H. Darton, of the United States Geological Survey, to whom the question of the age of this lava field was submitted, writes that, whereas "no quantitative data as to time are available, ... 500 years might be a reasonable guess and 1,000 years an outside limit." See also Guidebook of The Western United States, Part C, Santa Fe Route, Bull. 613, U. S. Geological Survey (page 158, plate XL).

geologically speaking. Here, it was, likewise, that Merriam, Bailey and Goldman had reported actual cases of modification in several different groups of rodents.

Despite the seemingly narrow scope of such an investigation, a somewhat intensive study of the San Francisco Mountain situation seemed warranted by the broader biological bearings of the chief problem involved. By the aid of funds contributed through the generosity of Mr. E. W. Scripps, an expedition was sent into this region in the fall of 1922, under the joint auspices of the Scripps Institution for Biological Research and the Museum of Vertebrate Zoölogy, both departments of the University of California. The party consisted of the two authors, together with Mr. R. R. Huestis, assistant and graduate student in the Scripps Institution. Following the return of Mr. Huestis to La Jolla, Mr. Carr H. Schwarz, of Flagstaff, Arizona, was employed as a temporary assistant.

After some reconnoitering, a base was established on September 5, at Dead Man Flat, on the high plateau northeast of San Francisco Mountain, and but a few miles from its base. The collection and preparation of specimens was carried on until November 12, when the senior author (the last in the field) discontinued operations.

We wish here to record our indebtedness to Messrs. Vernon Bailey and E. A. Goldman, of the United States Biological Survey, for helpful suggestions and information which contributed to the success of our labors. Mr. Goldman has likewise been good enough to examine some of our rodent specimens, belonging to several genera, with reference to their specific and subspecific identity, and to secure for us the loan of the type specimens of several of these subspecies.

Necessary data, regarding local conditions, ecological, topographical and meteorological, were placed at our disposal through the courtesy of various Forest Service officials, particularly Mr. G. A. Pearson of the Fort Valley Experiment Station and Mr. E. G. Miller, supervisor of the Coconino National Forest. Mr. Pearson has been good enough to inspect those pages of our manuscript relating to local ecological conditions.

Our hearty thanks are due to Dr. H. M. Hall, of the Carnegie Institution, for identifying a considerable collection of plant specimens, representing the more abundant species occurring at our various trapping stations, as well as for revising our lists of plant species. We must also record our indebtedness to Prof. A. C. Lawson, of the University of California, for information regarding rock samples from various

points in the region, and to Mr. H. H. Robinson, superintendent of the Connecticut Geological and Natural History Survey, for further information regarding the geology of the region visited.

Finally, it is a pleasure to acknowledge the never-failing helpfulness of Mr. and Mrs. W. J. Osborn, of Dead Man Flat, who contributed in many ways to our enjoyment, as well as to the successful outcome of our visit to this region.

Before proceeding with a detailed account of our operations and our results, it may be well to state in a few words the outcome of our labors. We were able, pretty promptly, to confirm the accounts of those authors who had reported the existence of races of rodents in the volcanic area surrounding San Francisco Mountain which were distinctly darker than those which were trapped in the adjacent Desert of the Little Colorado. Indeed, our evidence in this respect is based upon much larger series of specimens than have hitherto been collected in this region, and relates to species which have not been included among the illustrative cases.

On the other hand, the evidence to us seems pretty conclusive that the volcanic soil of the San Francisco Mountain plateau has not been a factor in the production of these color differences. In general the rodents of this region are not particularly dark in comparison with mountain or forest dwelling races from other parts of the southwest. They are only dark in comparison with the characteristically pale forms from the desert areas. Furthermore, we have what seems to be rather crucial evidence bearing against the alleged effect of the volcanic soil and rock formations, at least in this region. The data upon which these conclusions rest will be discussed at some length in the ensuing pages.

ACCOUNT OF THE REGION VISITED[3]

The San Francisco Mountains form a group of volcanic peaks and ridges which rise from the elevated plateau of northern Arizona to a maximum altitude of nearly 13,000 feet. The plateau region here varies in elevation from 6,000 to 8,000 feet. The entire "volcanic field," comprising the mountains and adjacent eruptive material, covers, according to Robinson, an area of over 2,000 square miles.

[3] Those who wish a more detailed account of the biological and geological features of this region should consult the works of Merriam (Results of a Biological Survey of the San Francisco Mountain Region and Desert of the Little Colorado, Arizona. North American Fauna, No. 3, Government Printing Office, 1890), and Robinson (The San Franciscan Volcanic Field, Arizona. U. S. Geological Survey, Professional Paper 76, 1913).

It was in this region, as is well known, that C. Hart Merriam first worked out the details of his life zone conception. Within this quite restricted area, he found represented all zones from the Lower Sonoran to the Alpine-Arctic, inclusive. Indeed the most casual inspection of this territory reveals the existence of some form of zonation, whether or not one accepts the general validity of any particular classification.

It is not, however, our purpose to discuss the life zones of this region except in so far as they relate to the problem at hand. The rodents which Merriam and others have supposed to be affected by the background of volcanic soil are all denizens of the piñon-juniper (Upper Sonoran) zone. Our own collecting operations—so far as they relate to this problem—were therefore confined to this zone and to the succeeding Lower Sonoran of the Little Colorado Desert. The ensuing remarks regarding the character of the volcanic territory refer, accordingly, to those portions which lie within the Upper Sonoran zone. The conditions at a greater altitude have not been carefully examined by us. It is worth stating, however, that, so far as we have observed, areas of bare volcanic rock and exposed dark colored soil seem to be no more prevalent in the yellow pine (Transition) zone than among the piñons and junipers lower down.

The eruptions which brought to the surface the volcanic materials of this region are assigned by Robinson to three distinct periods, lasting altogether from late Pliocene to recent times. During the last of these periods, cinder cones were formed and lava ejected which are estimated to cover about 1200 square miles. This period of eruption is attributed, for the most part, to the late Quarternary. From the degree of disintegration to which most of the lava of this region has been subjected, as well as the depth of the soil deposits which overlie it in many places, it is obvious that the volcanic activities represented in the San Francisco Mountain region are, as a whole, very much older than those which were responsible for the formation of the Mount Pisgah field in the Mojave Desert (p. 82). The most recent activities, occurring at the close of the third period, were limited to the formation of a few cones and lava fields, occupying an insignificant part of the entire area.[4]

Merriam likewise points out that San Francisco Mountain itself cannot be of more recent origin than the glacial period, since "its summit is inhabited by species of animals and plants which could not have

[4] After referring to the fact that the latest cones and flows are older than the pine trees growing in their vicinity, Robinson writes: "This would make them not less than 300 years old. Not improbably they may be as much as 1,000 years old."

reached it since the recession" of the ice. Thus the requirements of those who have insisted that the volcanic territory investigated should be both ancient and extensive are fully realized in the present case.

On the other hand one may readily derive a false impression from previous references to conditions within this territory, in their bearing upon the protective coloration hypothesis. While it is true that there are still a few square miles of dark, fresh looking lava (figure 2), which is not as yet covered, to any great extent, by soil or vegetation, this is not true of by far the greater part of the San Francisco Mountain region. Most of this area has long since been covered by soil, and upon the latter now flourish trees and shrubs, along with more or less abundant grass and other herbaceous plants. As a result of extensive journeying throughout this territory, and careful scrutiny from various elevated points, we must insist that the prevailing color tone of the ground, as thus seen, is not dark but pale. As partial exceptions to this statement are the summits and to some extent the slopes of the numerous cinder-cones, along with the relatively small areas of bare lava, referred to above. But the greater part of the level and gently sloping surfaces throughout this region display the pale gray hue of the rabbit-brush (*Chrysothamnus*) or the still paler straw color of the (usually dry) grass.[5] (Figures 4, 5.)

The foregoing statement applies strictly only to oblique views of the ground surface, and especially when the latter is seen from a distance. Under such conditions the bare patches of soil are overtopped by the vegetation, and are thus nearly or quite concealed from view. It must be admitted that a somewhat different impression is obtained when one views the ground surface from above and at short range. As is commonly the case in semi-arid regions, the vegetation does not form a continuous covering, but occurs in clumps, separated by areas of bare ground. In the region under discussion, both the clumps of vegetation and the intervening bare patches are of small size, ranging from a few inches to a few feet across, while the uncovered surfaces are commonly of less extent than the areas of turf (figures 10, 11). In sections which are occupied predominantly by rabbit-brush, this preponderance of vegetation is still more marked.

[5] Needless to say, the coniferous trees are of a decidedly dark hue, but these could hardly be supposed to influence the color of ground-dwelling animals. Moreover, the trees are commonly rather widely scattered, and they are nearly or quite absent throughout extensive "flats" or "parks," which occupy much of the Upper Sonoran territory in this region.

The exposed ground surface varies greatly throughout the region in question. Much of it consists of fine soil, of perhaps medium hue, but dark reds and browns are of rather frequent occurrence. Typically, the bare ground is covered by volcanic "cinders" or scoriæ, these ranging in color from pale brown to nearly black.[6] Tracts of wide extent may, indeed, be found, in which these scoriæ give a decidedly dark aspect to the bare portions of the ground (figure 3). It is such areas as these which Merriam and others have probably had in mind in their discussions of the darkening effect of volcanic soil upon rodents. So far as our observations have gone, however, these tracts of noticeably dark soil form but a small proportion of the total area of the San Francisco Mountain region. Furthermore, it must be emphasized that even here the closely spaced clumps of turf are decidedly pale in hue. In semi-arid regions such as this, the grass is green for only a small part of the year, and the green is seldom vivid. If it is true that a darkly colored rodent would be better concealed than a pale one, if resting on the bare ground, it is equally true that a pale rodent would be better concealed than a dark one, against a background of turf. (See figures 10, 11.)

Northeast of San Francisco Mountain (figure 1), the land slopes gradually from the base (about 8000 feet altitude) to the bed of the Little Colorado River (4000 feet). Following the road from Flagstaff to Tuba, in the Navajo Reservation, one descends the 3000 feet, from the belt of yellow pine to the Little Colorado in the course of a journey of about 35 miles. The passage from the yellow pine (Transition) zone to the zone of piñons and junipers (Upper Sonoran) seems, in general, to be fairly abrupt. On the other hand, the boundary between the piñon-juniper belt and the desert is far less obvious. The coniferous trees end, it is true, rather abruptly, but the succeeding territory, for many miles, is occupied by grassland, rather than desert proper. Extreme xerophytic conditions are not reached until one approaches within a few miles of the Little Colorado.[7] Thus the river, at least in this part of its course, lies much closer to the western than the eastern border of the desert. This fact must be borne in mind in interpreting certain facts of distribution.

[6] This layer of "cinders" is due to wind action. The entire soil is permeated by these volcanic pebbles, which are left behind when the lighter ingredients are blown away by the heavy gales of the region. Cultivated land if left untilled, soon reverts to its original appearance, owing to this action of the wind.

[7] Merriam uses the word "desert" rather loosely in this connection, including here the grassland area as far up as the piñon zone.

In spite of scattered outcroppings of dark volcanic rock, extending to, and even beyond, the Little Colorado, the prevailing rock formations of the Painted Desert[8] are non-volcanic. The most conspicuous rock of the region is a red sandstone, the weathering of which has given rise to extensive tracts of loose drifting sand, of a decidedly reddish hue.[9] At other points, the sand commonly has the more familiar buff tone of of our southwestern desert country, while throughout large areas the surface is covered with a layer of pebbles and rock fragments, which on the whole are likewise pale. As is usual in desert regions, the vegetation is sparse and widely scattered, leaving the greater part of the ground surface uncovered. Indeed there are extensive areas of shifting sand dunes, which are nearly or quite devoid of vegetation (figures 6–9).

In order to indicate to some extent the life conditions under which the animals of this region dwell, we here offer some rather meagre data relating to the meteorology and the flora of the localities in which we trapped. It is stated by Robinson that the mean temperature of the Little Colorado Valley is about 56°F., the average absolute maximum being 100°–105° and the minimum 0°. The mean annual rainfall is said by the same writer to be "less than 5 inches," while "in some years practically no rain falls in that area." These statements are based upon United States Weather Bureau records for Holbrook, Arizona.

At Tuba (4,500 feet), near which much of our desert trapping was done, the mean annual rainfall for a period of 23 years was 6.90 inches, according to United States Weather Bureau records. That bureau likewise informs us that the mean annual temperature at Tuba was 54.4° for this same period. The average of the annual maxima was 101° (12 years), that of the annual minima being 8°.

In the neighborhood of San Francisco Mountain, on the other hand, the mean annual temperatures are considerably lower and the rainfall much higher. Unfortunately, no data are available for Dead Man Flat and neighboring territory on the northeast side of the mountain. At Flagstaff on the opposite side of the mountain and at a slightly greater altitude, the temperature averages 44.5° (29 years), the average annual maximum being 89° and the average annual minimum −14°. The

[8] Here used synonymously with Desert of the Little Colorado.

[9] Mr. H. H. Robinson contributes the following note: "The red formation west of the Little Colorado is called the 'Moencopie', of Lower Triassic age. It is briefly described as chocolate-red and banded arenaceous shales and sandstones. The formation in the neighborhood of Tuba City is the Navajo sandstone of Jurassic age, described as light-red, massive, cross-bedded, fine and variegated sandstone."

mean annual rainfall at Flagstaff for this same period was 22.80 inches. It is quite certain, however, that the rainfall to the north and east of San Francisco Mountain is considerably lower than this, even at corresponding altitudes. Judging from general appearances, Mr. G. A. Pearson[10] offers an estimate of 15 inches for the annual rainfall of Dead Man Flat.

It is obvious to the visitor both that the rainfall is much lower and the percentage of sunshine much higher in the Painted Desert than in the more elevated land at the base of the mountains. We have on numerous occasions looked down upon the brilliantly lighted desert from our headquarters at Dead Man Flat, while heavy showers and overcast skies prevailed all about us in the upland region.

To the botanist it is likely that tables of the prevailing plants which occur in the localities under comparison will suggest a much more vivid picture of local climatic differences than these meagre meteorological data. The lists which are presented herewith make no pretense to even approximate completeness. Only the more conspicuous or abundant plants which were observed in a given locality were listed or preserved for subsequent identification.[11] In general, trees and shrubs were more likely to be noticed than herbaceous plants and annuals. Many fairly common species were deliberately omitted from the list, and many others were doubtless overlooked.

In listing these plants, the same grouping of localities will be employed as in the case of the trapping stations. Stations have been grouped together which represent the same type of locality—so far as the present problem is concerned—although these may have been ten or more miles distant from one another.

1. *Volcanic Areas in the Piñon-Juniper Zone* (Collections from a number of rather widely scattered points)

Pinaceæ

Pinus edulis Engelmann

Cupressaceæ

Juniperus utahensis (Engelmann) Lemmon

Juniperus monosperma Engelmann

Gnetaceæ

Ephedra viridis Coville

Gramineæ

Aristida californica Thurber

---

[10] In a letter to one of us.

[11] We again take pleasure in acknowledging the services of Dr. H. M. Hall, who identified most of these species, or confirmed identifications made in the field.

Bouteloua gracilis (H.B.K.) Lagasca
Bouteloua aristidoides (H.B.K.) Watson
Pleuraphis rigida Thurber
Liliaceæ
Yucca angustissima Engelmann
Chenopodiaceæ
Atriplex canescens (Pursh) Nuttall
Salsola kali Linnæus
Berberidaceæ
Berberis fremonti Torrey (probably)
Rosaceæ
Fallugia paradoxa (Don) Endlicher
Leguminosæ
Lotus wrightii (Gray) Greene
Astragalus diphysus Gray
Anacardiaceæ
Rhus trilobata Nuttall
Cactaceæ
Opuntia (at least two species)
Compositæ
Brickellia californica Torrey and Gray
Gutierrezia lucida Greene
Chrysothamnus nauseosus speciosus (Nuttall) Hall
Chrysothamnus nauseosus glareosus (Jones) Hall
Psilostrophe cooperi (Gray) Greene
Pericome caudata Gray
Senecio spartioides Torrey and Gray
Tetradymia canescens De Candolle

2. *Limestone Area in the Piñon-Juniper Zone* (Collection made within a single very restricted area)
Pinaceæ
Pinus edulis Engelmann
Cupressaceæ
Juniperus utahensis (Engelmann) Lemmon
Gramineæ
(Grasses not saved for identification)
Chenopodiaceæ
Atriplex canescens (Pursh) Nuttall
Compositæ
Senecio spartioides Torrey and Gray
Chrysothamnus nauseosus consimilis (Greene) Hall
Chrysothamnus stenophyllus (Gray) Greene

3. *Rocky Gorge of Little Colorado and Adjacent Desert Areas*
Gnetaceæ
Ephedra californica Watson
Gramineæ
Sporobolus airoides Torrey

Liliaceæ
Yucca angustissima Engelmann (or Y. glauca Nuttall)
Salicaceæ
Populus fremonti Watson
Chenopodiaceæ
Atriplex canescens (Pursh) Nuttall
Atriplex obovata Moquin
Capparidaceæ
Cleomella longipes Torrey
Rosaceæ
Fallugia paradoxa (Don) Endlicher
Prunus fasciculata (Torrey) Gray
Leguminosæ
Parryella filifolia Torrey and Gray
Prosopis juliflora glandulosa (Torrey) Cockerell
Oleaceæ
Fraxinus coriacea Watson
Adelia neomexicana (Gray) Kuntze
Labiatæ
Hedeoma incana Gray
Compositæ
Dicoria canescens Torrey and Gray
Chrysothamnus nauseosus glareosus (Jones) Hall
Isocoma acradenia Greene

4. *Little Colorado Desert, in Vicinity of Tuba* (Including species from border of a creek (starred) as well as those from open desert)
Gnetaceæ
Ephedra viridis Coville
Ephedra californica Watson
Gramineæ
*Phragmites communis Trinius
Liliaceæ
Yucca angustissima Engelmann (or Y. glauca Nuttall)
Salicaceæ
*Salix sp.
Polygonaceæ
Eriogonum sp.
Chenopodiaceæ
Atriplex canescens (Pursh) Nuttall
Atriplex confertifolia (Torrey) Watson
Sarcobatus vermiculatus Torrey
Suaeda moquini (Torrey) Greene
Salsola kali Linnæus
Amaranthaceæ
*Amaranthus retroflexus Linnæus
Ranunculaceæ
*Clematis ligusticifolia Nuttall
Capparidaceæ

Cleomella longipes Torrey
Leguminosæ
*Melilotus alba Lamarck
Anacardiaceæ
Rhus trilobata Nuttall
Loasaceæ
*Mentzelia multiflora Gray
Cactaceæ
Opuntia (at least 2 species)
Oleaceæ
*Adelia neomexicana (Gray) Kuntze
Labiatæ
Hedeoma sp. (same as in list 3?)
Solanaceæ
Datura meteloides De Candolle
Compositæ
Gutierrezia lucida Greene
Chrysothamnus nauseosus consimilis (Greene) Hall
Chrysothamnus nauseosus graveolens (Nuttall) Piper
Chrysothamnus stenophyllus (Gray) Greene
Isocoma acradenia Greene
*Solidago occidentalis Nuttall
*Aster hesperius Gray
*Helianthus annuus Linnæus
Artemisia filifolia Torrey
Senecio spartioides Torrey and Gray
Senecio douglasi De Candolle
*Carduus sp.

METHODS AND MATERIAL

A large majority of the specimens dealt with in the present report were caught in live-traps of the "Delusion" type. A considerable number, however, were caught in spring-traps of the sort commonly used for rats and mice. A few of the squirrels were shot. Since it is not the object of the present paper to give a general report upon the collections obtained in the course of this trip, no inventory of specimens will be given here.[12] It may be said, however, that over 1200 "mice" (in the broad sense of the term) were caught in the live traps, comprising 12 species and at least 15 subspecies, while about 225 rodents, belonging to 21 species and subspecies, were caught in spring traps or shot. By no means all of these, however, were measured or saved as specimens.

[12] These comprised large numbers of birds and some reptiles, as well as mammals.

An automobile "touring-car," remodeled to serve as a truck, was an indispensable part of our equipment. When it is stated that our trapping stations were widely scattered, and that collections were made from localities as far as sixty miles from our base, the need of rapid transportation will be appreciated. The living part of our catch was brought back to our headquarters in specially constructed chests, the animals being killed, measured and skinned at our convenience.[13] Indeed, a considerable number of the specimens were sent alive to La Jolla, where they were skinned later. Such as were plainly immature were kept for some months before skinning.

The quantitative data presented in the following pages are based almost entirely upon specimens which had been caught in the live-traps. These were measured by the senior author, according to methods already briefly described.[14] For use in the instrumental color determinations, flat skins were prepared in the manner which has been followed in previous studies. An important part of this technique consists in the thorough removal of grease by means of benzine.[15]

The color determinations were conducted, as in the past, with the aid of the Hess-Ives Tint Photometer. The procedure employed in the use of this instrument has been discussed briefly in two previous papers,[16] and no further account will be offered at the present time. A more adequate discussion of this instrument and its uses in biological research is contemplated for publication in the near future.

It should be stated at this point, however, that the conclusions reached in the present paper are not based entirely upon strictly quantitative data, derived from the study of flat skins. The considerable number of filled "study skins" have supplemented the latter in a valuable way, while many specimens were examined in the field which were not skinned at all.

[13] The advantages of using live-traps for catching certain species of rodents are very great, but we cannot dwell upon this point here.

[14] American Naturalist, April-May, 1918.

[15] Under laboratory conditions, each skin is subjected to a uniform degree of tension by means of a series of eight radially arranged weights and pulleys, after which it is pinned to a block of wood and allowed to dry for about ten days before cleaning. For various reasons, this stretching-frame has not been used in the field. Here the skins are stretched slightly by hand, while being pinned to the drying blocks. Under desert conditions in summer, a mouse skin may lose much of its elasticity by the time that it has been removed from the body.

[16] Journal of Mammalogy, May, 1921, (pp. 77, 84); Journal of Experimental Zoology, Oct., 1922, (foot-notes on pp. 289, 294).

As already indicated in the foregoing lists of plants, our trapping stations have been grouped into four series (figure 1). The first group comprised stations in Dead Man Flat and all other points in the Piñon-Juniper zone, where the soil and rock formations were volcanic. These stations lay at altitudes between 6,000 and 7,000 feet, the majority being not far from 6,500 feet.[17] The greater part of the specimens were taken on open, level ground, incompletely covered by scattered clumps of turf and rabbit-brush. The most successful catches were made in the immediate vicinity of cultivated land. On several occasions the number of specimens taken in the live-traps in a single night nearly or quite equalled the total number of traps set. In this first series of stations are likewise comprised a few localities on the summits and slopes of cinder-cones, and one rather extensive field of fairly fresh lava (figure 2).

The second region to be considered actually comprised but a single trapping station. This lay in a northwesterly direction, at a distance of about thirty miles from Dead Man Flat, on the southern margin of T 28 N, R 5 E. It had closely the same altitude as the former locality, but was situated in a very different geological formation. This point was selected because of its bearing on the question whether the color of the soil has played any part in bringing about the differences of coat color between the desert and upland races of rodents. The exposed rock of this region was the Kaibab Limestone. The trapping station was removed eight to ten miles from the nearest conspicuous outcropping of volcanic material, and further yet from any extensive areas of this sort. The specimens were trapped, for the most part, in open flats, bordered by dense growths of piñons and junipers, and incompletely covered, as elsewhere, by scattered clumps of grass and rabbit brush. The soil, in many places, was strewn with fragments of very light colored limestone and chert (figures 14, 15), though not otherwise conspicuously pale.

The third group of trapping stations was in the vicinity of the Little Colorado River. Part of the specimens were taken in rocky gorges connecting with the main canyon of the river, not far from the bridge on the Tuba road (Cameron Post Office). The remainder were trapped in a quite different sort of territory, in the open desert, four to six miles east of the river.

[17] Most of the trapping in the volcanic area was carried on at Dead Man Flat, within the township T 24 N, R 8 E. Two other townships in this region, T 25 N, R 8 E and T 26 N, R 7 E were also visited for trapping purposes. The latter contains a relatively recent lava field, a few square miles in extent.

The last series of stations were located in the neighborhood of Tuba City, the western agency of the Navajo Indian Reservation. This settlement lies northeast of the aforementioned bridge, and about 20 miles, in an air line, from the nearest point of the river. Its altitude is about 4500 feet. It is largely a region of loose, reddish sand, and, excepting in the neighborhood of creeks or irrigation canals, the vegetation is of a typically xerophytic character. Two trips of several days each were made to this region, and abundant specimens were trapped. The record catch of 165 mice, taken in 100 traps in a single night, was made on the border of an irrigated tract, cultivated by Indians.

The following table indicates the species and subspecies of rodents which have been studied by us, in relation to the problem of color modification. The number of individuals trapped (or shot) is likewise included, as well as the number which were preserved as specimens, both in the form of flat skins and of study-skins of the more usual type. It should not be necessary to state that care was taken to avoid selection on the basis of color, in choosing the specimens for skinning. Practically all available individuals of these species were skinned, except in the case of *Peromyscus*, the numbers of which were too great to allow of this. Immature specimens and those with damaged pelts were rejected,[18] otherwise the specimens were chosen entirely at random.

	TYPE OF LOCALITY	NUMBER TAKEN	NUMBER SKINNED
Citellus spilosoma obsidianus	Volcanic	9	9
Perognathus flavus fuliginosus	Volcanic	19	19
Perognathus flavus bimaculatus	Desert, near Little Colorado River	20	20
Onychomys leucogaster fuliginosus	Volcanic	55	55
Onychomys leucogaster fuliginosus	Limestone	3	3
Onychomys leucogaster melanophrys	Desert, mainly near Tuba	41	39
Peromyscus maniculatus rufinus	Volcanic	600(±)	131
Peromyscus maniculatus rufinus	Limestone	88	45
Peromyscus maniculatus rufinus (or *sonoriensis*?)	Desert, mainly near Tuba	200(+)	100

[18] This is strictly true only of specimens in the juvenile pelage. We have thus far discovered no certain way of distinguishing the first post-juvenile pelage from later, and more truly "mature" ones, so that our material doubtless includes a certain proportion in the former stage. The differences between the second and later pelages are, however, commonly small in comparison with the racial differences among these mice, and in any case we have excluded the possibility of any "systematic error" due to this cause (see p. 106).

The *Citellus*, *Perognathus* and *Onychomys* represent the three species cited by Merriam (Biological Survey of the San Francisco Mountain Region) as illustrating the modification of mammalian coat color by a background of volcanic soil. Our most extensive series of skins, however, belongs to a species (*Peromyscus maniculatus*) which was not referred to by Merriam in this connection, but which has yielded results of high interest.

Another mouse, *Reithrodontomys megalotis megalotis*, should be mentioned in passing, although, owing to the small number of specimens, it has not been included in the above table. About 20 specimens were trapped in the volcanic region and 15 in the vicinity of Tuba. Of these, 10 and 7 specimens respectively were prepared as study skins. A larger number would have been prepared, had the color differences between the two series been recognized in the field.

One of the commonest mice of the region was *Peromyscus truei truei*. We early began the preparation of a considerable series of skins of this species, in the hope of being able to make an instructive comparison. But *P. truei* was not trapped in sufficient numbers in the more typical portions of the Painted Desert. Specimens from the rocky gorges in the vicinity of the Little Colorado show no significant differences from those trapped at Dead Man Flat and vicinity.

The attempt was also made to collect sufficient numbers of *Peromyscus crinitus* (here represented by the subspecies *auripectus*), the species which was earlier discussed in relation to the lava field in the Mojave Desert. *P. crinitus auripectus* was fairly common in the canyon region of the Little Colorado, but was not taken at Tuba. It was likewise not trapped on Dead Man Flat or vicinity. Of the four specimens which were taken upon a lava field about 12 miles from the latter point (about 6000 feet elevation) it happens that one is noticeably darker than any adult skin in the series of 33 from the neighborhood of the Little Colorado. The remaining three are close to the average of the latter, however, and it is plain that no conclusions are warranted from the material at hand.

ANALYSIS OF THE DATA

1. Citellus spilosoma obsidianus[19]

This subspecies of ground-squirrel was described by Merriam from two specimens taken in "the disintegrated lava soil of the cedar belt . . . . . northeast of San Francisco Mountain." It was said to exhibit "the darkest phase of coloration yet observed in the species" and was cited, along with certain other "striking illustrations of the law of color adaptation." "*Spermophilus spilosoma obsidianus*", as he then called it, was contrasted on the one hand with the lighter colored *S. s. pratensis*, which was said to inhabit "the grassy openings or parks of the pine belt," and on the other with the yet paler "*Spermophilus cryptospilotus*" of the Painted Desert.

Nine specimens of *Citellus spilosoma obsidianus* were obtained by us from Dead Man Flat. These were prepared as study skins, so that instrumental analysis is out of question. No specimens were taken of the two paler forms described by Merriam. While these squirrels from the piñon-juniper belt vary widely among themselves both in respect to color and to the distinctness of their markings, it may be freely granted that they are all of a considerably darker hue than most ground squirrels from the desert. They are not, however, exceptionally dark, when compared with various mountain or coast-dwelling forms, from regions in which the soil is not volcanic. Reference to museum series of California ground-squirrels shows that the color of our *Citellus* from Dead Man Flat may be matched fairly well by *C. beecheyi beecheyi*, *C. beecheyi fisheri* (particularly specimens from the San Jacinto Mountains), and *C. douglasii*. Indeed, the latter species is much darker than this San Francisco Mountain form, and has an almost jet-black patch on the back, which the latter lacks entirely.

[19] Mr. Goldman informs us that he regards *C. s. obsidianus* and *C. s. pratensis* as synonymous, and that he plans to include both of them under the latter name, this having priority. We have here followed Merriam in employing the name *obsidianus* for the specimens from the piñon-juniper belt, though with no thought of disputing Goldman's opinion as to the identity of the two forms.

We have compared our nine skins of "*obsidianus*" with the type and six topotypes, collected by Merriam and Bailey in 1889. On the whole the latter are plainly redder and somewhat darker than our specimens, but we cannot feel sure that the older material has not undergone a change of color in the course of time. It is significant that the skin, as well as the hair, of these earlier specimens shows a reddish-brown hue, in strong contrast to that of our own material.

If it be objected that the comparison is here made with a quite distinct species, one may fairly reply that this comparison is quite relevant to a discussion of the protective coloration hypothesis. Our contention is that the darker color of San Francisco Mountain ground-squirrels, in comparison with those of the desert, cannot be attributed to the volcanic nature of the soil, nor to any other factors in the color tone of the background. The cases just cited tend to support the view that this is merely one instance, among innumerable others, of the general correlation between body color and atmospheric humidity or rainfall.

2. Perognathus flavus fuliginosus and P. flavus bimaculatus

Merriam's "*Perognathus fuliginosus*" was based on a single "immature specimen . . . . captured in the cedar and piñon zone on the black lava or 'malpais' northeast of the mountain." It was said to be "modified in the same manner and for the same reason as *Onychomys fuliginosus*," another of Merriam's instances of a protectively colored rodent.

Goldman[20] has likewise described a dark subspecies of pocket-mouse, *Perognathus apache cleomophila* from the vicinity of Winona, a station about fifteen miles east of Flagstaff. Of this he writes: "The dark coloration of the upper parts harmonizes well with that of the decomposed lava or cinders of its local habitat and contrasts correspondingly with that of *P. a. apache* and the lighter sands it inhabits."

We obtained 19 specimens of *Perognathus flavus fuliginosus* from Dead Man Flat and vicinity and 20 specimens of *P. f. bimaculatus* from the Painted Desert, chiefly from the open sandy section some miles from the Little Colorado River. These figures indicate the scarcity of this species in comparison with various other mice of the region.

A very casual inspection suffices to show the marked differences of color tone between these two subspecies. Whereas in both races the dorsal region of the pelage is abundantly sprinkled with black hairs, that of the upland form is much the darker of the two, being in extreme cases nearly black along the mid-dorsal line. Figure 12 shows the lightest and (nearly) the darkest of the flat skins from each of these races. It should be stated that these differences are shown much less strikingly by photographs than by the skins themselves. The mean

[20] Proceedings of the Biological Society of Washington, May 16, 1918.

color values, in terms of "black," "white" and "color"[21] are indicated by the following table, which is based upon the limited number of adult flat skins available for the purpose. Two juvenile flat skins belonging to the "volcanic" series are correspondingly dark, while the considerable number of "study skins" from adult specimens of the latter further emphasize the distinctness of these two races. So far as available specimens are concerned, it may be said that the two series do not overlap one another at all in respect to color characters. The "volcanic" race is consistently darker and less highly colored.

Perognathus flavus (adult)

	VOLCANIC (9)	DESERT (13)
Black	87.3	78.8
White	7.7	10.9
Color	5.0	10.3

General reasons have already been given for doubting the alleged effect of the volcanic soil in bringing about the dark color of its rodent inhabitants. As regards the present species, it may be said that, in some specimens at least, the "protection" has been *greatly overdone*, the dorsal surface of the animals being much darker than the average soil color of the region, and darker than any except the blackest of the cinders.[22] It is, moreover, of interest to point out that two other subspecies of *Perognathus flavus*, *P. f. mexicanus* and *P. f. perniger*, show this same tendency toward a darkening of the pelage. Of the former subspecies, Osgood[23] writes that "many are almost as dark as *fuliginosus*." There is nothing in Osgood's text to indicate that these were collected in volcanic areas, though Mr. Goldman states that "the

[21] For reasons which we shall not justify here, the difference between the highest color-screen reading (red) and 100 per cent is regarded as the percentage of "black," the lowest reading (blue-violet) is regarded as indicating the percentage of "white," while the remainder is credited to (free) "color." The ratio between the figures for "free" red and green (after deducting the amounts regarded as contributing to the composition of the white light present) constitutes the "Red: Green ratio" which is referred to below. It is a rough index of the spectral position of the "free" color. No exact value for the latter is given by the readings and this, indeed, is not required for present purposes.

[22] This statement has been checked by comparison with actual samples of these materials.

[23] Revision of the Pocket-Mice of the Genus Perognathus. North American Fauna no. 18, U. S. Department of Agriculture, 1900.

soils in the higher part of the Mexican table land are rather dark in color." *P. f. perniger* occurs in South Dakota, on "rather heavy soil," Mr. Bailey states.

3. Onychomys leucogaster fuliginosus, and O. l. melanophrys

Four specimens of an *Onychomys* were described by Merriam from the vicinity of San Francisco Mountain, and referred to a new species, *O. fuliginosus*. Three of these were said to have been taken on lava beds at Black Tank (12 to 15 miles north of Dead Man Flat). Of this form Merriam writes that "its dark, almost blackish, coloration, unique in the genus, is in as complete accord with the prevailing color of the decomposed lava and 'malpais' soil on which it lives as the pallid-cinnamon tints of its congener of the Painted Desert are with its environment." Merriam regards it as certain that the dark, upland form was differentiated in very recent times from the desert race, which presumably entered the Painted Desert, after the excavation of the latter, by way of the Colorado River.

Here again, we were able, very promptly, to confirm Merriam's statement as to the marked differences of color between the desert and the upland races. The latter animals, to be sure, were not found to be phenomenally dark as Merriam's small series seemed to indicate, but rather of a general color-tone widely prevalent among rodents from non-desert regions.[24] The former, on the other hand, are not only exceptionally pale, even for a desert race, but are highly colored as well. So far as comparison with any single "standard" color is possible, the lateral regions of the pelts of our collection seem to be intermediate between Ridgway's "cinnamon" and "cinnamon buff." The dorsal region, as usual, contains a larger proportion of black hairs.[25]

In figure 13, are shown our darkest and palest adult flat skins of each of these subspecies. It will be seen that there is no overlapping of the two series. Furthermore, the difference in hair pigment is almost as clearly shown on the ventral as on the dorsal side. In general, there is a considerable slaty zone at the basal ends of the ventral hairs

[24] Through the kindness of Mr. Goldman, we have been able to examine three of Merriam's original specimens. The type, a fully adult specimen, appears to be darker than the darkest of our adults, but this may be due to the greasy condition of the fur. The other two are immature.

[25] For more detailed comparisons between these subspecies, see Hollister: A Systematic Account of the Grasshopper Mice, Proceedings U. S. National Museum, vol. 47, 1914, pp. 427–489.

in *fuliginosus* while this is much less developed, and may in places be quite lacking in the desert race. For this reason the ventral pelage of the latter looks intensely white, while that of the former has a slightly grayish appearance.

The differences in the coat color of these two races are shown in a quantitative way in the following tables.

Onychomys leucogaster (adult)

	VOLCANIC (8)	DESERT (24)	LIMESTONE (1)
Black	82.5	70.5	78.5
White	9.8	13.6	11.0
Color	7.7	15.9	10.5

Onychomys leucogaster (immature)

	VOLCANIC (17)	DESERT (7)	LIMESTONE (2)
Black	84.9	74.4	81.7
White	9.7	14.3	11.3
Color	5.4	11.3	7.0

In the tables are likewise given the figures for three specimens of this species which were taken at the trapping station in the limestone territory. Of these three specimens, one of the immature individuals gives readings which are very close to the average values for the immature specimens from the volcanic country. The other two are paler, though both are considerably nearer the means for the volcanic series than the means for the desert series. In the aggregate, the three "limestone" specimens lie about twice as close to the former as the latter, and it seems proper, therefore, to assign them to "*fuliginosus*," rather than to "*melanophrys*." On the other hand, it must be admitted that their condition is to some extent intermediate, though this fact may have no significance.

Two immature specimens of this species were taken in the Painted Desert, near the Little Colorado. These are likewise somewhat intermediate between the Tuba and Dead Man series, but, in the present case they lie closer to the former than to the latter.

In respect to one other character besides coat color the upland and the desert races of *Onychomys* are found to differ widely from one another. The width of the dorsal tail stripe (considered as a percentage of the circumference of the tail) gives us a mean value of 44.2 for

the former and 32.8 for the latter. These figures are based upon 25 and 24 specimens respectively.[26] The difference is here nearly equal to that between *Peromyscus maniculatus rubidus* and *P. m. sonoriensis*, belonging to the northern California coast and to the Mojave Desert, respectively.

On the other hand these races of *Onychomys* show no difference in respect to the pigmentation of the hind foot. Every foot which was examined was assigned to the "0" grade of pigmentation,[27] with the exception of a single specimen, belonging to the volcanic series, which showed a low grade of pigmentation ("1").

As in the case of the species previously considered, there seems to be no good reason for attributing the differences between these two subspecies of *Onychomys* to differences in the color of the soil. The doubtful nature of the "protection" afforded by the color of *fuliginosus* against a mixed background of pale turf and dark soil, has been already discussed (p. 87 and figures 10, 11).

As a further reason for questioning the origin of the dark color of *O. l. fuliginosus* as a protective adaptation may be mentioned the fact that both species of *Onychomys*, *O. leucogaster* and *O. torridus*, contain subspecies nearly or quite as dark as *fuliginosus*. In some of these cases, at least, the color-tone of the background can hardly be invoked as an explanation.

4. Peromyscus maniculatus rufinus and P. m. sonoriensis (?)

Merriam described as a new subspecies "*Hesperomys leucopus rufinus*," from San Francisco Mountain, at an altitude of 9,000 feet, and lists 24 specimens from this mountain, without further specifications as to locality. He also lists 10 specimens of "*Hesperomys leucopus sonoriensis*" from the "Painted Desert," although it is evident from the text that 7 of these were taken from lava beds near "Black Tank," far above the desert proper. He makes no comparison between these two races in respect to color, which may readily be accounted for, in view of the relatively slight differences here shown and the small size of Merriam's series.

We have no desire to involve ourselves in any discussion of the sub-

[26] The tail stripe presented too indefinite an outline in many of the desert specimens to allow of its being measured.

[27] See Sumner, Journal of Experimental Zoölogy, April, 1920.

specific position of the mice here to be considered by us.[28] That they all belong to the more inclusive species known as *Peromyscus maniculatus* is beyond doubt. Our present task is to compare collections made at our four groups of trapping stations with one another and, incidentally, with certain races from more distant points. For the purposes at hand, the nomenclature used is quite immaterial.

The specimens from the volcanic districts in the piñon-juniper zone are appreciably smaller, on the average, than those taken in the vicinity of Tuba. The two collections (each including numerous immature, though not juvenile, specimens) average 86.5 and 90.0 millimeters in body length (body + head), respectively, these figures being based upon 131 and 99 individuals.[29] This difference in length is further indicated by the fact that 11 of the Tuba series reach a length of over 95 millimeters, while only one of the volcanic series reaches this length, despite the larger numbers comprised. Except for this difference in mean size, the significant differences which we have observed between these two races all relate to the pigmentation of the hair and skin.[30]

Unlike the cases of *Perognathus* and *Onychomys*, which have been discussed above, the differences between these local collections of *Peromyscus* are shown only by a comparison of considerable numbers. Many specimens from the volcanic district are as pale as average specimens from the desert, while a few from the desert are very nearly as dark as the darkest from the volcanic district. Each series presents a wide range of variability. Nevertheless, the mean differences between these two races, in respect to a number of pigmental characters, while small, are of absolutely certain significance. In only one case among those listed ("color") is the difference statistically doubtful. The other quotients $\frac{\text{(difference)}}{\text{probable error}}$ range from 4 to 17.5 in magnitude.

[28] Osgood (Revision of the Mice of the American Genus Peromyscus) assigns to *sonoriensis* the 11 specimens from the Painted Desert which were examined by him, and to *rufinus* the 28 specimens from San Francisco Mountain.

[29] All specimens smaller than 80 millimeters in body length have been excluded from these computations.

[30] Of course this difference in body-size involves corresponding size-differences of all the parts, but these absolute differences are not what are here referred to. When the lengths of the various appendages are reduced to a standard body-length of 90 millimeters (Sumner, Journal of Experimental Zoology, April, 1920), the differences are slight or non-significant.

Peromyscus maniculatus

	VOLCANIC (110)	TUBA (75)	DIFFERENCE (VOLCANIC AND TUBA)	LIMESTONE (43)
Black	83.2±0.13	80.7±0.23	2.5 ±0.26	82.8±0.17
White	8.7±0.07	10.8±0.10	2.1 ±0.12	9.2±0.08
Color	8.1±0.09	8.5±0.18	0.4 ±0.20	8.0±0.12
Red:Green ratio	2.99±0.02	2.85±0.02	0.14±0.028	2.95±0.03
Tail stripe*	28.9±0.22	27.1±0.23	1.8 ±0.32	27.1±0.28
Foot pigmentation*	1.48±0.05	1.22±0.04	0.26±0.064	1.37±0.08

* The figures for these characters are based upon larger numbers of individuals than those for hair color. The numbers in this case are 131, 99, and 57, respectively, for the three series.

Since the three components "black," "white" and "color" in every case total 100 per cent, they are not, of course, independent variables. The more black is present, for example, the less white and color. On the other hand, the red: green ratio is not correlated in the least with the darkness or paleness of the skin. It is of interest to point out the small though significant difference between these ratios for the "volcanic" and "desert" series. This corresponds to the fact that even a naked-eye comparison of these series seems to show a larger proportion of *reddish* skins among the former and a larger proportion of *yellowish* ones among the latter. The last circumstance is quite independent of the difference in shade, due to differing proportions of black. It is interesting to note that these same differences, both in respect to shade and to color, have been found to obtain between *P. m. sonoriensis* and some other races, especially *P. m. rubidus*, in California.

The difference in the mean width of the tail stripe is so small that it was not detected until the measurements were averaged. It appears, however, to be a real one, being about 5½ times its probable error. This difference, likewise is of the same sort (though less in degree) as that between desert and non-desert races in California.

Another difference to be noted is that in respect to the pigmentation of the hind foot. This difference likewise appears to be statistically significant, being four times its probable error. Here again, we are dealing with one of the characters which distinguish *P. m. sonoriensis* from the darker races *gambeli* and *rubidus*. It must be admitted, however, that in the Arizona case we can not be at all certain that this difference between our mountain and desert series has any biological

significance. Foot pigmentation is found to be in a considerable degree correlated with body length (perhaps due to changes with age). When due allowance is made for this factor, the difference between these races is so far diminished that we cannot be sure it is not accidental.

It must, however, be pointed out in this connection that none of the other pigmental differences here considered can be due to possible differences in the mean size or age of the series. No correlation whatever has been detected between body length and the relative width of the tail stripe. While the same cannot be said of body length and coat-color[31] steps have been taken to eliminate this possible source of error.

To test this point the mice of each of our two chief races ("Tuba" and "Volcanic") were divided into groups of approximately the same body length, and the mean of the character in question (e.g. "black") was determined for each of the size groups. Thus the comparisons between the two races could be limited to groups of individuals of approximately the same size. While it is not worth while to encumber this report by figures or graphs, illustrating these relations in detail, we are able to say that such a treatment of our material leaves unaffected the differences between these two races in respect to coat color.

One of the important features of the foregoing table is the comparison which it permits between the limestone series and the two major series considered in these studies. Eighty-eight specimens of *P. m. rufinus* were trapped in this last region, of which 57 were measured, and 45 skinned.[32]

Examining these last figures in detail we find that the limestone series averages slightly paler than the volcanic one, though the difference is not of probable significance. On the other hand, the former series is undoubtedly darker than the desert one. On the whole, it seems fair to say that, in respect to color, the limestone mice belong to the upland

[31] Coat color is known to change with age, at least during the earlier months of life. For this or some other reason, it has been found that certain series of mice show an inverse correlation between body length and the percentage of black in the hair. Such a correlation seems to hold in the case of the *P. m. rufinus*, belonging to our "volcanic" race.

[32] A larger series, representing this critical locality, would have been desirable. On the occasion of our first trip to the limestone district, we were seeking primarily for *Perognathus* and *Onychomys*. Since it was not at that time realized that *Peromyscus* showed any local differences throughout the entire region, few specimens were saved. A later visit was made in November, after severe winter weather had commenced. These weather conditions unfortunately made it necessary for us to abandon field work rather hurriedly.

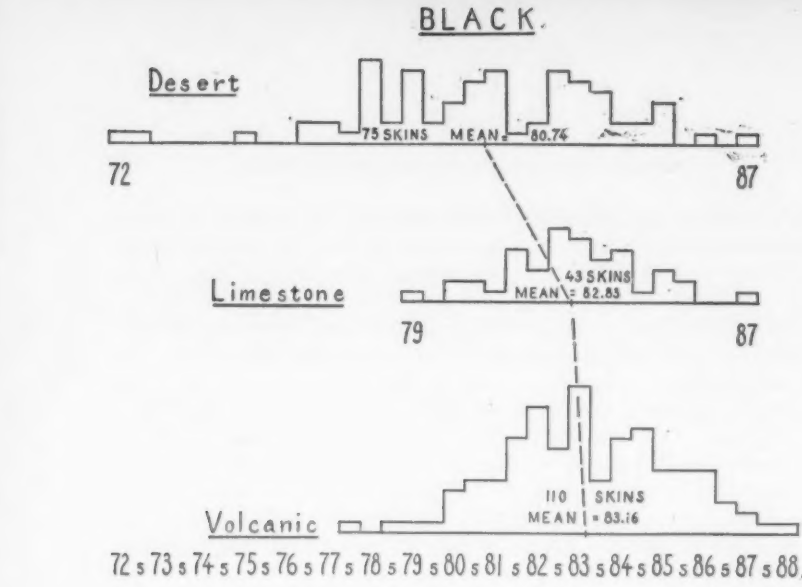
rather than to the desert type. This is likewise true in respect to size, so far as we may judge by the series measured. The mean body length of the 57 specimens is 85.0, the maximum being 91.5. These figures are even lower than those for the volcanic lot.

Considering the two remaining pigmental characters, the relations of this series are found to be different. As regards foot pigmentation, the limestone mice appear to be about intermediate between the two major series, though the situation, as has just been mentioned, is complicated by the existence of size-differences among the three lots concerned. In respect to tail-stripe, however, the limestone series gives a mean value which is identical with that of the desert mice, rather than with that of the "volcanic" ones. This fact is rather surprising since, in general, width of tail stripe and depth of color tend to vary together, whether we consider races or individuals. It seems obvious, however, that this character has but a remote bearing on the protective coloration hypothesis.

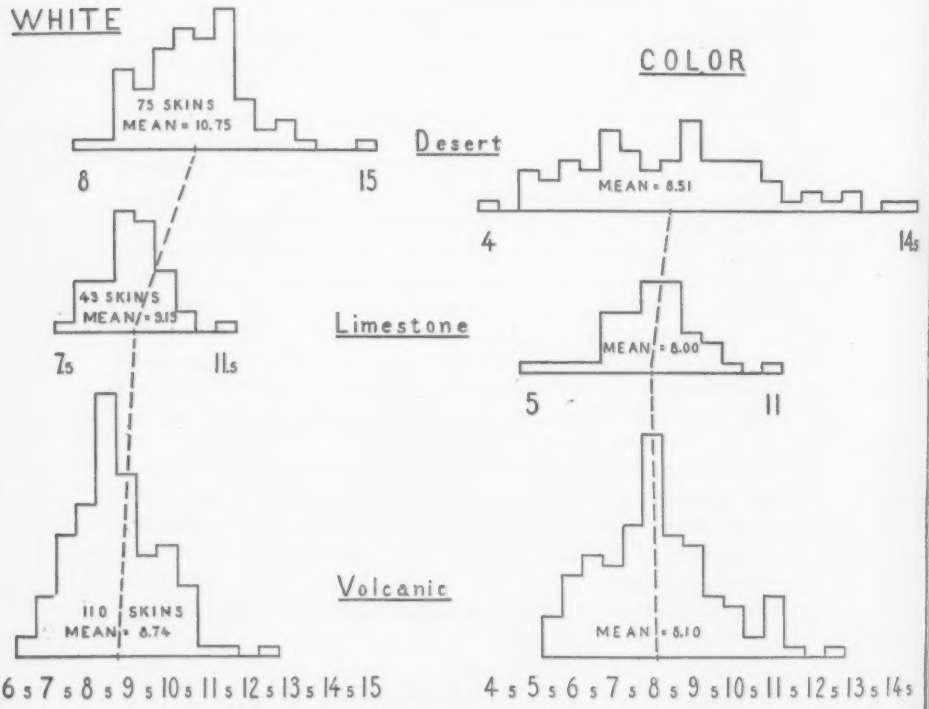
The foregoing table deals only with mean values, and gives no idea of the range of variability within the several series of skins. In the histograms are shown the frequency distributions for each of the three related characters ("black," "white," and "color") and for each of our three local collections.

The course of the dotted lines connecting the means of the respective histograms shows in a graphic way the relative magnitudes of these means in the three series. Very obvious is the broad overlapping of the distributions for each of the three characters under consideration, indicating the lack of any distinctness of type, except as an average condition. Of interest, too, is the far greater range of variability of the desert race in comparison with either of the others. A preliminary examination of skins had shown that the desert series, while containing by far the palest skins of the collection, likewise comprised some which were nearly as dark as the very darkest. The possibility suggests itself that the Tuba population consists of a mixture of two different local races (perhaps *rufinus* and *sonoriensis*), which meet in this territory. We have, however, no further data on this point.

A small number (17) of skins were prepared, taken from specimens trapped near the gorge of the Little Colorado River (third group stations). Aside from their limited number, this series of skins was poorly prepared, being somewhat shrunken and puckered. For this reason, only 11 were available for quantitative color determinations. We are not, therefore, warranted in devoting much attention to these


BLACK
Desert
75 SKINS MEAN = 80.74
72
87
Limestone
43 SKINS MEAN = 82.85
79
87
Volcanic
110 SKINS MEAN = 83.16
72 s 73 s 74 s 75 s 76 s 77 s 78 s 79 s 80 s 81 s 82 s 83 s 84 s 85 s 86 s 87 s 88.

HISTOGRAMS, SHOWING PERCENTAGES OF "BLACK" FOR EACH OF THE THREE PRINCIPAL SERIES OF PEROMYSCUS MANICULATUS, DISCUSSED IN THIS REPORT



HISTOGRAMS, SHOWING PERCENTAGES OF "WHITE" AND "COLOR," FOR PEROMYSCUS MANICULATUS

mice, nor in basing any conclusions of importance upon them. It need only be said that on the average they are intermediate in shade between the "volcanic" series and that taken at Tuba, a point considerably nearer the heart of the Painted Desert. No particularly pale specimens are included in this small series, the lowest value for "black" being 80 per cent, as compared with 72 per cent in the Tuba lot.

To recapitulate the evidence derived from *Peromyscus maniculatus*, we may say that the upland mice (whether from volcanic or limestone territory) average somewhat smaller than the desert ones (at least those of the Tuba lot), and that they average somewhat darker than the latter in respect to coat color. Mice from the volcanic territory likewise have a slightly broader average tail stripe, and slightly darker feet than those from the Tuba district.

The limestone series, while very slightly paler than the volcanic series, agrees with the latter in being significantly darker than the desert race. In respect to tail stripe, on the other hand, the limestone mice agree with those from the desert.

Specimens from the vicinity of the Little Colorado River appear to be intermediate in coat color between desert and upland forms, but the series is not large enough to allow of any conclusions.

As in the case of the rodents previously discussed, there would seem to be no reason for attributing the slightly darker hue of the upland deer-mice to any influence of the color tone of the ground upon which they live. Aside from the general considerations which were dealt with in our discussion of the local environment, we have in this case something in the nature of an experimental "control" permitting us to differentiate between the effects of meteorological and soil conditions. Such a control is furnished by our series from the limestone district.

Here, too, as in the other cases, it should be borne in mind that the upland forms are dark only in comparison with those of the desert. The specimens of *P. m. rufinus* from the neighborhood of San Francisco Mountain are, in reality, of almost exactly the same shade as specimens of *P. m. gambeli* from the coastal region of southern California and from Calistoga, at the head of Napa Valley.[33]

Furthermore, it must be pointed out that the upland and desert races of the portions of Arizona visited by us differ far less in respect to nearly all these pigmental characters than do *gambeli* and *sonoriensis*,

[33] This applies strictly only to the percentage of "black." The proportions of "white" and "color" are somewhat different in the three cases mentioned.

from climatically contrasted regions of southern California. The following table gives the values for these same characters in the two latter races.

Peromyscus maniculatus gambeli and P. m. sonoriensis (Southern California)

	LA JOLLA (COAST)	VICTORVILLE (DESERT)
Black	83.47±0.23	78.06±0.24
White	9.70±0.13	11.00±0.12
Color	6.83±0.16	10.94±0.18
Red:Green ratio	2.96±0.04	2.94±0.03
Tail stripe	32.31±0 26	23.12±0.24
Foot pigmentation	1.88±0.09	0.90±0.07

If differences in pigmentation are due to differences in the color-tone of the background, we should hardly expect these to be so much greater in the case of the two California races than in the case of the two Arizona ones. The relations are more in harmony with the known fact that the differences in climatic conditions are far greater between the California stations under consideration than between the Arizona ones.[34]

In this connection it must be insisted that *Peromyscus*, as well as *Onychomys* and *Perognathus*, are almost exclusively nocturnal in their habits. The following test affords striking evidence of this fact. One hundred live traps were baited and set on Dead Man Flat shortly before noon (10:30 to 12:30). They were inspected at the close of the afternoon (4:45 to 5:55,—the sun set about 5:30). Not a single trap was found to contain a mouse. On the following morning, these 100 traps contained exactly 100 mice, 95 of which were *Peromyscus maniculatus rufinus*, the others being *Reithrodontomys*.

While it is not claimed that nocturnal animals have no need whatever for protective coloration, the need would seem to be far less urgent than in the case of diurnal ones.

[34] It may well be that the much greater *distance* between the contrasted stations in California has played a part in the matter. Were atmospheric humidity the only factor concerned we should expect the La Jolla mice to be far *darker* than those from Dead Man Flat. But no such strict proportionality in the effects of this factor are claimed to exist.

5. Reithrodontomys megalotis megalotis.[35]

Seven study skins of this species from the neighborhood of Tuba City were compared with 10 from Dead Man Flat. The former, as a series, are paler than the latter, not only as regards the general hue of the dorsal and ventral surfaces of the body, but likewise as regards the color of the snout region and the dorsal surfaces of the feet. Such a distinction in color-tone could not, it is true, be maintained for every specimen of one series in comparison with every specimen of the other. But it holds for the two series in the aggregate, and the difference was commented upon independently by five different observers. Even more pronounced than this difference in the average shade of the pelage is a difference in the distribution of the light and dark hairs. In the upland form the pelage presents a more homogeneous color-tone.

The small number of specimens[36] renders the result of such a comparison inconclusive, but it is quite in keeping with the relations just described for *Peromyscus maniculatus*.

SUMMARY AND CONCLUSIONS

1. We are able to confirm the statements of Merriam, Bailey and Goldman that certain rodents of the volcanic region surrounding San Francisco Mountain, Arizona, are darker than their nearest relatives in the Desert of the Little Colorado (Painted Desert), not many miles distant.

2. With regard to both *Onychomys leucogaster* and *Perognathus flavus*, the two local subspecies are so widely distinct that there is little or no overlapping of their ranges of variation, in respect to coat color. In *Onychomys* the difference relates to the width of the tail stripe, as well as to the color of the pelage.

3. *Citellus spilosoma obsidianus*, the remaining one of the three rodents mentioned by Merriam as being specially adapted to a dark background of volcanic soil, is represented in our collections by nine specimens. We did not, however, obtain specimens of the paler subspecies reported by Merriam as inhabiting nearby non-volcanic areas.

4. Two very limited series of the harvest-mouse (*Reithrodontomys megalotis megalotis*) exhibited local differences, comparable with those shown by the *Peromyscus* next to be discussed.

[35] Mr. Goldman assigns all of our specimens to this subspecies.

[36] Many more were trapped, but few were skinned, owing to our first impression that these two local races agreed very closely in shade.

5. Considerable collections of skins of *Peromyscus maniculatus* reveal the existence of a small but significant mean difference between specimens taken in the volcanic regions of the piñon-juniper belt (6,000–7,000 feet) and a point in the Painted Desert, about 50 miles distant and 2,000 feet lower in altitude. The upland race is darker and slightly redder on the average than the desert race, as well as being somewhat smaller. Likewise the dorsal tail stripe is somewhat broader in the former, and the feet more deeply pigmented.

6. In order to test the question whether this difference has been due to the adaptation of the upland race to a background of particularly dark soil, a control series of mice of the last named species was trapped in a limestone region, at the same elevation as the volcanic territory, but about ten miles removed from the nearest outflow of volcanic material. The "limestone" series of mice were found to be very nearly, though not quite, as dark as the "volcanic" series. The situation here is quite in harmony with that described by the senior author in relation to the species *Peromyscus crinitus*, from volcanic and non-volcanic regions of the Mojave Desert.

7. A further reason for doubting the alleged influence of the color-tone of the background upon the coat-color of these rodents lies in the fact that the ground surface is, in reality, not exceptionally dark throughout much of this volcanic region, while the soil everywhere (except in very limited fields of exposed lava) is partially covered by clumps of turf and low shrubs (mainly *Chrysothamnus*). Since both of these last are commonly of a pale hue, they give to most of this territory a predominantly light colored aspect, rather than a dark colored one, when viewed from a short distance.

8. Pointing to the same conclusion is the fact that these darker rodents of the upland districts are only dark in comparison with related forms from the neighboring deserts. They are not particularly dark when compared with other mountain and coast-dwelling races. This is true, at least, of the species of *Peromyscus*, *Onychomys* and *Citellus*, here considered. It is perhaps not true of one species of *Perognathus* (*P. flavus*) which is admittedly dark—darker, probably, than most of the bare ground in the region which it inhabits. We must, however, call attention here to the existence of other dark subspecies of *Perognathus flavus*, which have been described from regions not known to be volcanic.

9. For these and other reasons, it seems to us more likely that climatic factors, rather than the optical properties of the background, are

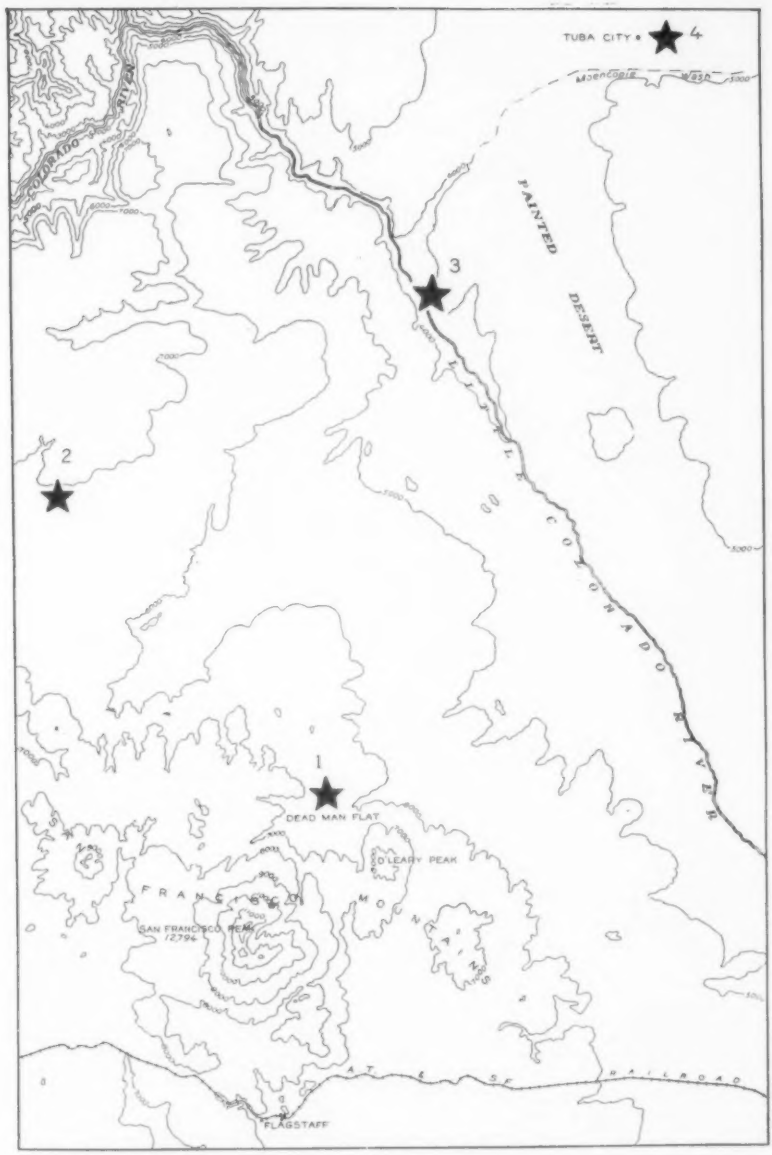


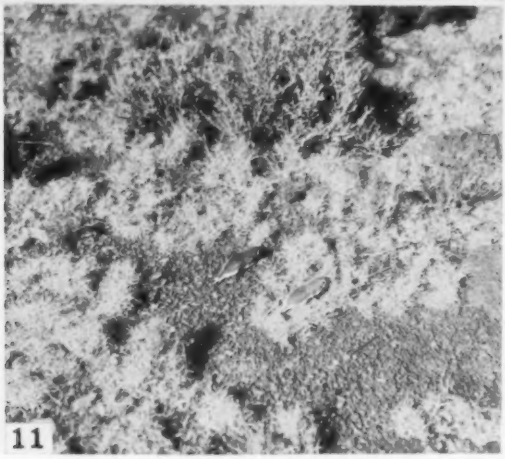
Fig. 1. Map showing region discussed in present paper, based upon U. S. Geological Survey quadrangles "San Francisco Mt." and "Echo Cliffs." Stars indicate approximate position of principal areas in which rodents were collected. (1) Dead Man Flat, representing volcanic territory in piñon-juniper zone; (2) the limestone station; (3) stations in vicinity of Little Colorado River; (4) stations near Tuba City.

(Sumner and Swarth: Color of Mammals)

Fig. 2. Edge of lava field (T 26 N, R 7 E), not far from "Black Tank" of Merriam's San Francisco Mountain report. Fig. 3. Area covered with exceptionally dark volcanic "cinders" and having ground comparatively little concealed by turf and shrubs. Fig. 4. Dead Man Flat, showing turf and brush, covering greater part of ground surface. This is more typical of condition within volcanic area. (San Francisco Mountain in the background.) Fig. 5. Another view of Dead Man Flat, from a slight elevation.

(Sumner and Swarth: Color of Mammals)

Fig. 6. Desert of the Little Colorado (Painted Desert),—an area in which surface is covered with coarse gravel. Figs. 7, 8, 9. Painted Desert, near Tuba,—region of drifting sand and widely scattered vegetation.



Figs. 10, 11. Skins of *Onychomys leucogaster fuliginosus* and *O. l. melanophrys*, against a mixed background of volcanic cinders and pale, straw-colored turf. The color-tone of *melanophrys* seems to harmonize as well with the latter background as *fuliginosus* does with the former. (For the purpose of these photographs areas were selected having more than average proportions of dark cinders.)

(Sumner and Swarth: Color of Mammals)

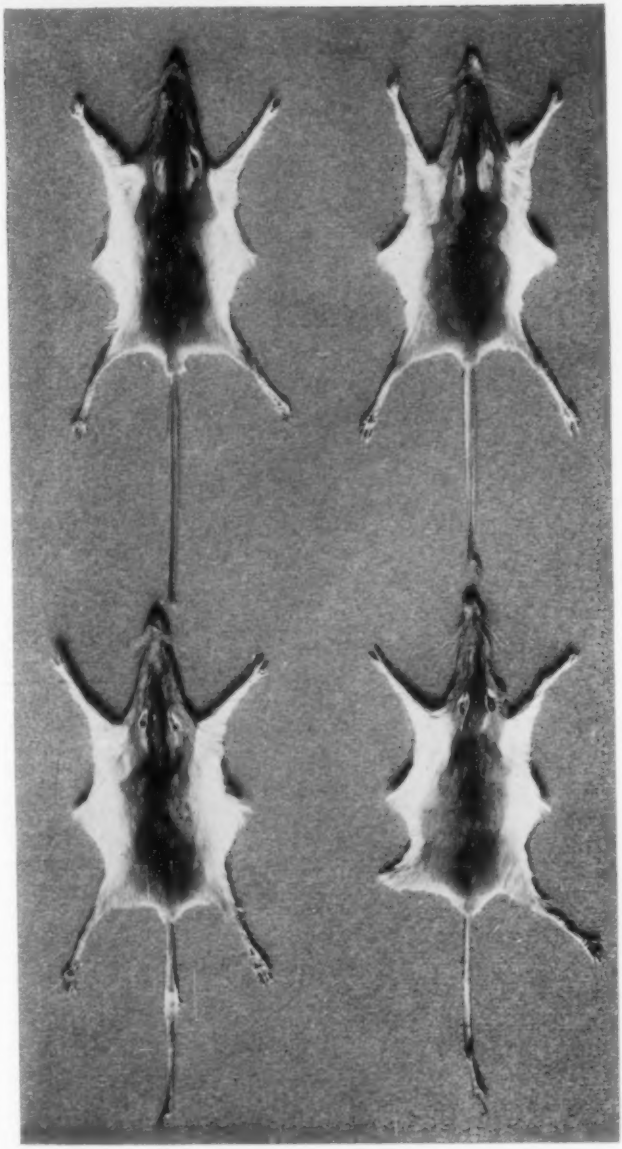


Fig. 12. The darkest (except one) and palest flat skins of *Perognathus flavus fuliginosus* (above), and the darkest and palest skins of *P. f. bimaculatus* (below). The darkest skin of *fuliginosus* is considerably darker than that here shown, but has not been figured owing to poor preservation.

(Sumner and Swarth: Color of Mammals)

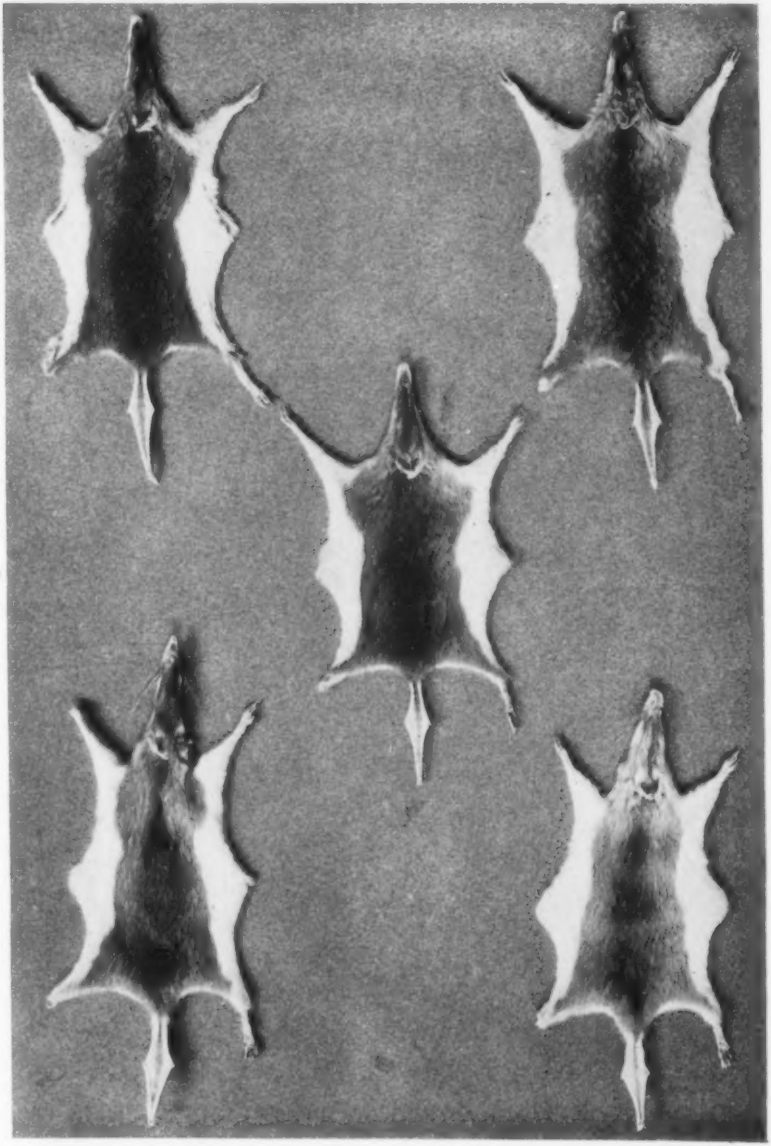


Fig. 13. Above: darkest and palest flat skins of *Onychomys leucogaster fuliginosus* from Dead Man Flat. Center: single mature skin of same subspecies from limestone region. Below: darkest and palest *O. l. melanophrys* from vicinity of Tuba City.

(Sumner and Swarth: Color of Mammals)

Fig. 14. Region of Kaibab limestone. Open "flat" or "park," surrounded by piñon-juniper forest. (The "limestone" series of mice were trapped here.) Fig. 15. (See figure 14.) The larger white areas are snow, the smaller ones are due to pale rock fragments.

(Sumner and Swarth: Color of Mammals)

responsible for the differences of color between rodents from San Francisco Mountain and the Desert of the Little Colorado. Of these various factors it seems probable that atmospheric humidity (including rainfall, which must affect the humidity of the air within the burrows) is the most important. As to how this factor acts—whether directly or indirectly—we have no knowledge at present. In any case, it doubtless acts in conjunction with other unknown factors in the production of these differences of pigmentation. The protective coloration hypothesis, while having a wide applicability in nature, does not seem to account satisfactorily for the color differences between desert dwelling mammals and the denizens of more humid climates.

Scripps Institution, La Jolla, Calif., and Museum of Vertebrate Zoology, Berkeley, Calif.

WHERE DO WILD ELEPHANTS DIE?

By Lieut. Colonel Gordon Casserly, F.R.G.S.

One of the strangest mysteries of zoology is the question of where wild elephants die. And it is a mystery that has never yet been solved. In India and Burma where these great animals still roam the jungles in herds fifty to a hundred strong, in Ceylon and Siam, as in Africa, legends have grown up concerning hidden death-places lost in the heart of vast forests or untrodden mountains to which they retreat when instinct tells them that their end draws near. I have used the idea myself in my novel "The Elephant God" in which I described the marvellous Terai Jungle at the foot of the Himalayas and imagined a concealed valley in the awful solitudes of the remote snow peaks above it, to which the great herds made pilgrimage to accompany to their last resting place those of their members about to die.

But though I lived for years in that far-extending jungle in which these great beasts abound and in the hills that overshadow it, though I have ranged widely through the green labyrinths of its woodlands—once for twelve days on end from dawn to dusk I pursued relentlessly on a tame elephant a murderous "rogue" wild elephant that was the terror of the forest and tracked its zigzag flight through many strange places—I have never seen the carcass of one of these big mammals that died a natural death. Nor, although I have asked jungle tribesmen, hunters white and brown, planters and forest officers who have

passed half their lives in the Terai, and mahouts, who are a race apart, a race in which father and son through generations serve My Lord the Elephant in his captivity, have I met anyone more fortunate. I have questioned men acquainted with the jungles of Assam and Burma and always met with the same answer.

In India the greatest authority on elephants is still the late E. P. Sanderson who was the officer in charge of the Government Elephant Catching Establishemnt in Mysore and had experience as well of expeditions to catch them in the wild hill-tracts of Chittagong and the Garrow Hills in Bengal. He has written a book that is a classic, a book with a ponderous title, "Thirteen Years Among the Wild Beasts of India: Their Haunts and Habits From Personal Observation; With an Account of the Modes of Capturing and Taming Elephants." I cannot do better than quote largely from it.

One of the most remarkable facts in connection with elephants is the extreme rarity of any remains of dead ones being found in the jungles. This circumstance is so marked as to have given rise to the notion amongst the Shōlagas of the Billiga-rungun hills that elephants never die; whilst the Kurrabas of Kákankoté believe that there is a place, unseen by human eye, to which they retire to end their days. In my own wanderings for some years through elephant-jungles I have only seen the remains of one female (that we knew had died in calving), and one drowned elephant brought down by a mountain torrent. Not only have I never myself seen the remains of any elephant that had died a natural death, but I have never met any one amongst the jungle-tribes, or professional elephant-hunters, who had seen a carcass, except at a time when murrain visited the Chittagong and Kákankoté forests. Bones would not decay for some years, and teeth and tusks would survive for some time, yet not a single pair of ivories has ever, as far as I know, been found in the Mysore jungles during the time I have known them. In Chittagong, in January 1876, I found a portion of a large tusk in a morass, much eaten by exposure; it weighed 33 lb. Another was found in Tipperah, almost fossilized; weighing 36 lb.; there were no other remains in either case.

The fact of remains of bison, deer, and other wild animals seldom being found is equally singular. Their bones would be sooner disposed of than those of elephants; still it is strange that, except in cases of epidemics amongst these animals, they are hardly ever seen. Certain classes of wild animals may possibly retreat to quiet localities when they find their powers failing them, as places where alarms and necessity for flight are unlikely to overtake them. But this is not the case with such gregarious animals as elephants. It may be supposed that in thick forests vultures do not attract attention to their carcasses, and monsoon rains and jungle-fires soon dispose of them. Still one would think that some carcasses at least would be found, whereas they never are; and though it is certain the animals do die, I know of no reasonable explanation of what becomes of them.

The following interesting reference to the subject of dead elephants never being seen is made by Sir Emerson Tennent in his *Wild Elephant*. I venture to quote it as showing the similarity of opinion of the natives of Ceylon and the wild tribes of Mysore:

"The natives generally assert that the body of a dead elephant is seldom or never to be discovered in the woods. And certain it is that frequenters of the forest with whom I have conversed, whether European or Singhalese, are consistent in their assurances that they have never found the remains of an elephant that had died a natural death. One chief, the Wanyyah of the Trincomalie district, told a friend of mine, that once after a severe murrain which had swept the province, he found the carcasses of elephants that had died of the disease. On the other hand, a European gentlemen, who for thirty-six years, without intermission, had been living in the jungle, ascending to the summits of mountains in the prosecution of the trigonometrical survey, and penetrating valleys in tracing roads and opening means of communication—one, too, who has made the habits of the wild elephant a subject of constant observation and study—has often expressed to me his astonishment that, after seeing many thousands of living elephants in all possible situations, he had never yet found a single skeleton of a dead one, except of those which had fallen by the rifle.

"The Singhalese have a superstition in relation to the close of life in the elephant: they believe that, on feeling the approach of dissolution, he repairs to a solitary valley, and there resigns himself to death. A native who accompanied Mr. Cripps when hunting in the forests of Anarájapoora, intimated to him that he was then in the immediate vicinity of the spot 'to which the elephants come to die,' but that it was so mysteriously concealed that, although every one believed in its existence, no one had ever succeeded in penetrating to it. At the corral, which I have described at Kornegalle, in 1847, Dekigame, one of the Kandyan chiefs, assured me it was the universal belief of his countrymen that the elephants, when about to die, resorted to a valley in Saffragím among the mountains to the east of Adam's Peak, which was reached by a narrow pass with walls of rock on either side, and that here, by the side of a lake of clear water, they took their last repose."

A similar mystery cloaks the death of wild elephants in Africa. Yet it must be remembered that a dead one, if a male with tusks, is always valuable—in that continent much more so than a living one, for there these animals cannot be tamed and trained as Asiatic ones are—on account of its ivory and so would be eagerly sought for. Their tusks are bigger than those of Indian elephants, yet these are not to be despised. From one which Sanderson shot in Mysore he obtained seventy-four and a half pounds of ivory, one tusk being five feet in length, the other four feet eleven inches, measured on the outside curve. He tells of another shot by Sir Victor Brooke and Col. Douglas Hamilton that had one giant tusk eight feet long, weighing ninety pounds, while the other, being diseased and broken, was only three

and a quarter feet in length and forty-nine pounds in weight. With ivory the price it is the carcass or skeleton of a dead tusker would be well worth finding; and one can imagine what a valuable discovery would be the last resting-place of generations of elephants.

But apparently no man has ever gazed on such a Golgotha. Yet the idea of a vast death-place of these modern mammoths hidden in the remote recesses of the Himalayas did not seem a far-fetched one to me when I lived in the shadow of those mighty mountains and heard at night the great elephant troops pass by the little outpost that I commanded on the frontier of Bhutan as they climbed up towards the snowclad peaks from the Terai Forest below.

New Malden, Surrey, England.

REMOVAL OF THE TESTICLE IN A SIKA DEER FOLLOWED BY DEFORMITY OF THE ANTLER ON THE OPPOSITE SIDE

By Charles B. Penrose, M.D.

[*Plates 13–15*]

Several years ago I was told by a British sportsman that there was a widespread idea among the game keepers and sportsmen of his country that if a deer had a deformed antler on one side, the testicle on the opposite side was likely to be injured or absent. Prompted by this statement I made the following observations on two Japanese sika deer at the Philadelphia Zoological Garden:

Deer No. I. A mature male, 12 years old, with well developed unusually symmetrical normal antlers, of the sika pattern with a brow tine and three other points on each side. Length of each antler on the outer curve 17½ inches. The right testicle was removed October 23, 1919; the cord and vessels were ligated in one ligature and the skin wound was left open. The antlers were shed April 12, 1920. The next antlers, which were developed by the fall of 1920, were the ones in which the effect of removal of the testicle might be apparent. Both antlers were stunted in comparison with those of the previous year. The right had four points, including the brow, and was 13½ inches in length; the left was somewhat tortuous, 14½ inches long, and had only one small point one inch in length at the top of the beam (figure 1).

Fig. 1.—Sika deer No. I. Right testicle removed October 23, 1919. The picture shows the first antlers grown after removal of testicle.

Fig. 2.—Sika deer No. I. Right testicle removed October 23, 1919. The picture shows the second antlers grown after the operation, the fall of 1921.

(Penrose: Sika Deer)

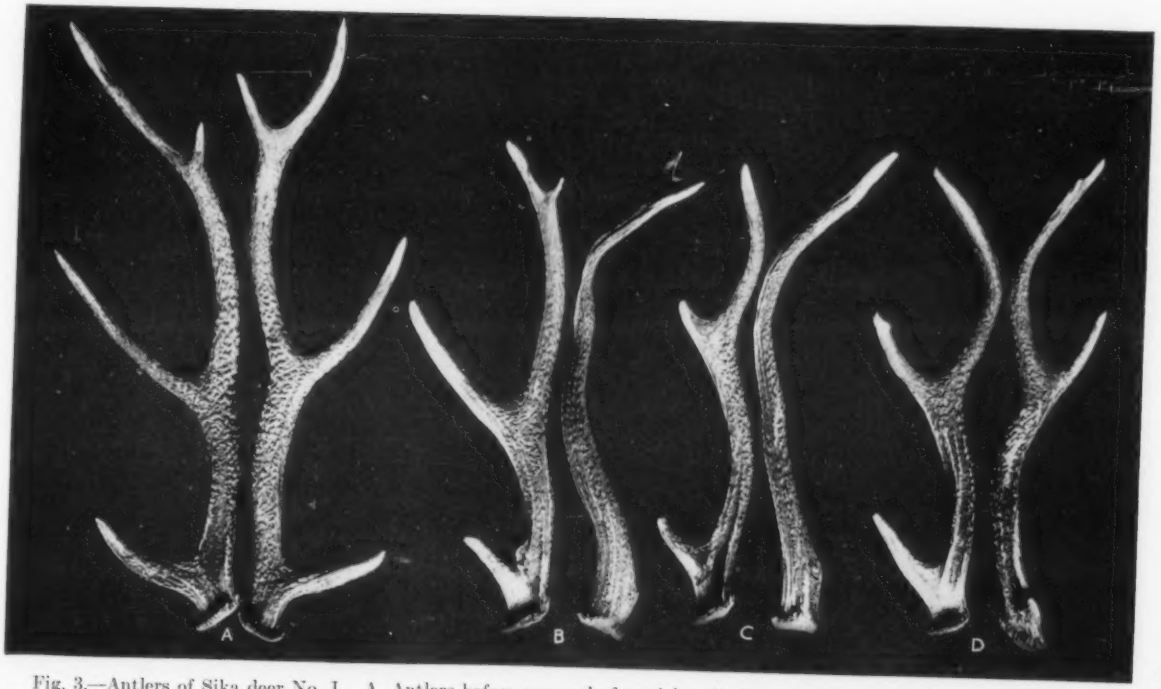


Fig. 3.—Antlers of Sika deer No. 1. A. Antlers before removal of testicle. B. First antlers grown after removal of testicle. C. Second antlers grown after removal of testicle. D. Third antlers grown after removal of testicle.

(Penrose: Sika Deer)

Fig. 4.—Sika deer No. II. Before removal of left testicle.

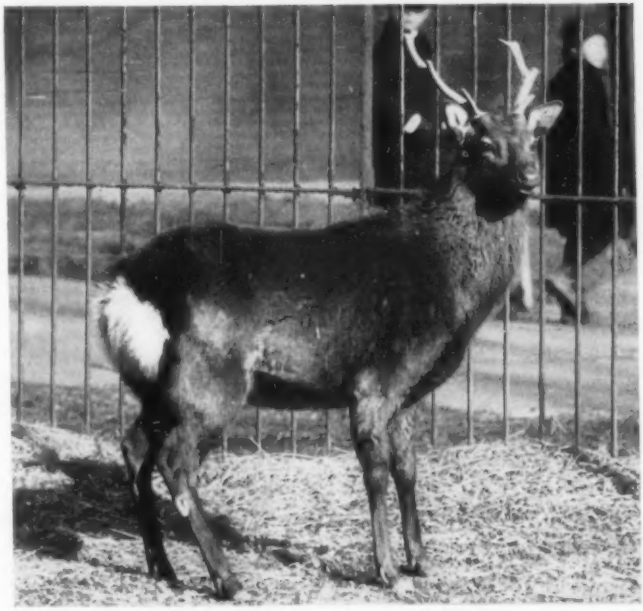


Fig. 5.—Sika deer No. II. Left testicle removed October 24, 1920. The picture shows the first antlers grown after removal of testicle. The points and beam have been worn away by rubbing against the bars.

(Penrose: Sika Deer)

These antlers were shed: the right, March 26, 1921; the left, March 30, 1921. The antlers developed in the fall of 1921 are shown in figure 2. The right antler was stunted, 13½ inches long, with three points; the left was a spike 14¾ inches long, with no points. These antlers were shed,—the right on April 3, 1922, the left on April 5, 1922. The next antlers, the third after the operation, were approximately of the normal type and symmetry, though stunted. They were shed April 4, 1923. The right antler measured 13½ inches, the left 14 inches. They are shown in figure 3, D.

If the removal of the testicle affected the symmetry of the antlers in the two years immediately following the operation, this effect appears to have gone by the third year, though the effect on the size of the antlers remains. The change in the antler was a reversion to the primitive or immature type.

Deer No. II. A mature male 7 years old, younger than No. I, with well developed, slightly asymmetrical normal antlers, with four points on the right side and five points on the left side (figure 4). The left testicle was removed October 24, 1920, in the same way as in deer No. I. The right antler was shed April 16, 1921, the left antler April 15, 1921. The points and beams of the antlers had been worn away by rubbing against the bars of the enclosure to less than half the original size, so that no measurements were made. The following fall, October, 1921, new antlers were developed, somewhat smaller than the original ones, but symmetrical and normal in appearance, with four points on each side. Figure 5 shows this first growth of antlers after removal of the left testicle. It will be seen that they are symmetrical and well developed, though the points and beam are worn away by the persistent rubbing against the bars of the enclosure, to which this deer was addicted. For this reason no measurements were made of the antlers, though those grown after removal of the testicle appeared to be decidedly smaller than the original antlers. The pictures show this difference in size.

The following year deer No. II again had normal symmetrical antlers, though they were smaller than the original ones. The experiment on deer No. II is negative as to the effect of removal of the left testicle on the symmetry of the antlers. The operation, however, was followed by a diminution in the size of the antlers subsequently grown.

In these experiments the testicles were removed by the same operator, by the same method, at the same time of year, and on animals of mature age.

No scientific deduction, however, can be drawn from them, one being positive and the other negative. It may be that the two testicles exert different influences on secondary sexual characters.

The experiments apparently lend some support to the tradition of game keepers and sportsmen that a deformed antler may be due to injury to a testicle on the opposite side, and the result is interesting enough to encourage further investigation. I regret that thus far it has been impossible for me to follow the subject up. I believe that a cross effect of removal of a testicle on a secondary sexual character has not been recorded.

1331 Spruce Street, Philadelphia, Pa.

TWO NEW MURINE RODENTS FROM KURILE ISLANDS, JAPAN

By Nagamichi Kuroda

The following two species of Muridæ from Kurile Islands seem to me to be undescribed.

Microtus uchidæ sp. nov.

1 ♀ juv. (type), Paramushir, Northern Kurile Islands, August, 1918 (no. 971; Ishino coll.; presented to me by Mr. S. Uchida).

Diagnosis.—Similar to *Microtus montebelli* of Hondo, Japan, but the general coloration much paler. The underparts of body yellowish-brown; the dorsal parts darker and somewhat washed with rufous; the under fur of back slaty color, tipped with yellowish-brown and intermixed with longer brown hairs; underparts from chin to breast pale yellowish-buff and abdomen only paler; the basal parts of the fur of underparts slaty color somewhat paler than those of the upper parts, and tipped with yellowish-buff; the border of upper and underparts not well defined; upper surface of hands and feet yellowish-brown, the toes covered with white hairs; tail sharply bicolor, the upper surface brown and lower surface white; ears brown with some yellowish-brown hairs; the basal half of longer whiskers brown and apical half white; shorter whiskers dark brown, a few white ones near muzzle. Length of longer hair on back about 12 mm.; shorter fur about 10 mm. on the same region.

Dimensions.[1]—Head and body 88 mm.; tail 30 mm.; hind foot 17.5 mm.; ear 10 mm.

Skull.—Greatest length 23.5 mm.; basilar length (damaged); zygomatic breadth 13 mm.; length of nasals 6.5 mm.; interorbital breadth 4 mm.; diastema 7.5 mm.; palatilar length 12 mm.; foramen incisivum 4.1 mm.; length of upper molar series 5.9 mm.; breadth of m^1 1.5 mm.

[1] Dimensions taken from the type specimen in spirits.

Teeth.—The convex angles of teeth are sharp, much like those in *M. montebelli*, but m^3 and m_1 are very differently characterized. The m^3 has 4 convex and 4 concave angles on the outer side instead of 3 convex and 3 concave angles as in *montebelli;* and m_1 lacks 2 convex angles at the apex on the outer side, so that it has only 3 convex and 3 concave angles on the same side instead of 5 convex and 4 concave angles as in *montebelli*.

The species, *uchidæ*, is apparently intermediate between *M. kamtschaticus* (Polyakoff) and *M. montebelli* (M.-Edwards) as its distribution shows.

Habitat.—Northern Kurile Islands: Paramushir Island. It is said that it is also distributed in the islands of Simusir and Onekotan in the Northern Kuriles.

Mus kurilensis sp. nov.

1 ♂ ad. (type) and 1 ♂ juv., Shimoshiri, Central Kurile Islands, August, 1918 (nos. 969, 970; Ishino coll.; presented to me by Mr. S. Uchida).

Diagnosis.—General color of upper parts near "ochraceous tawny" of Ridgway's Color Standards and Color Nomenclature, in adult specimen, the dorsal area distinctly darker than sides and rump; in young specimen the upper parts uniformly colored; under fur of back slaty color tipped with "ochraceous tawny" and intermingled with long dark brown hairs; fur of underparts pale ashy-gray tipped with "cream buff" of Ridgway; the border of upper and underparts not well defined; upper surface of hands and feet covered with silvery white hairs, somewhat mixed with brown hairs; tail distinctly longer than head and body, the upper parts of tail covered with short brown hairs and the underparts of it covered with white or whitish brown hairs; ears brown covered with short hairs; longer whiskers brown and a few shorter ones near muzzle white. Fur on back about 7.5 mm. in length.

Dimensions.[2]—

SEX	HEAD AND BODY	TAIL	HIND FOOT	EAR
	mm.	mm.	mm.	mm.
♂ ad. (type)	84	86	17.5	15
♂ juv	67	74	16	12

Skull.—Greatest length 23.8 mm. (ad.), 20.8 + x mm. (juv.); basilar length 18.8 mm. (ad.), 16 + x mm. (juv.); zygomatic breadth 11.1 mm. (ad.), 10 mm. (juv.); length of nasals 9 mm. (ad.), 7.8 mm. (juv.); interorbital breadth 3.9 mm. (ad.), 3.8 mm. (juv.); diastema 6 mm. (ad.), 5 mm. (juv.); palatilar length 10 mm. (ad.), 9.2 mm. (juv.); foramen incisivum 5 mm. (ad.), 4 mm. (juv.); length of upper molar series 4 mm. (ad.), 3.5 mm. (juv.); breadth of m^1 1.2 mm. (ad. and juv.).

The new species, *kurilensis*, is easily distinguished from *M. molossinus* Temminck by its underparts "cream buff" instead of whitish, by the tail being longer than head and body, and by the skull larger and longer than that of *molossinus*.

Habitat.—Central Kurile Islands: Shimoshiri Island.

Tokyo, Japan.

[2] Dimensions taken from specimens in spirits.

THE TYPE-SPECIMEN OF SAUROCETUS GIBBESII AGASSIZ

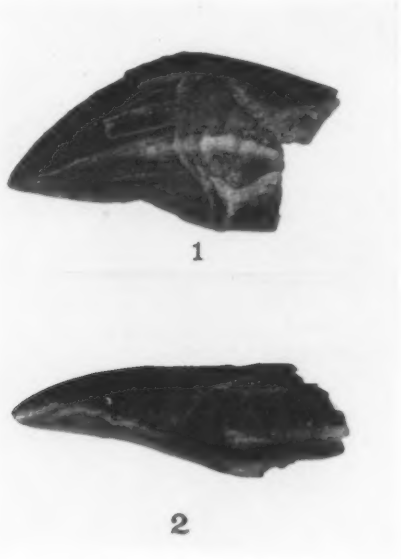
By Glover M. Allen

[*Plate 16*]

In 1848, a letter from Louis Agassiz to Robert W. Gibbes was published in the Proceedings of the Academy of Natural Sciences of Philadelphia (vol. 4, p. 4) remarking on the distinction of *Basilosaurus* from *Dorudon* and briefly describing the tooth of another fossil cetacean from South Carolina. Of this last he says: "The fossil tooth, though imperfect, is highly interesting, as indicating a new genus of Sauroid Cetacea, allied to Megalosaurus by the form of the tooth, but differing by the form of its root. I would propose to call it *Sauro-cetus Gibbesii*. It will easily be distinguished from the fang of Dorudon, by its great flatness and acute serrated edge. In the form of these anterior teeth there is another generic difference between Zeuglodon [= Basilosaurus] and Dorudon, worth mentioning; in the former being blunt and short, whilst Dorudon has them acute and sharp upon the edges."

This letter written in December, 1847, from Charleston, South Carolina, where Agassiz was then staying, contains all the information yet published as to this new cetacean. Probably it was Agassiz's intention to describe and figure the specimen in a projected monograph on certain fossil species, but this was never brought to fruition, and the name has since been quoted in bibliographies and lists without further elucidation. Doctor Hay in his list of Fossil Vertebrata of North America, 1902, includes it among the zeuglodonts (Basilosauridæ) as "a genus of uncertain position."

What is without doubt the original specimen is still preserved in the Museum of Comparative Zoölogy, accompanied by a small label with the words, "Squalodon tooth, S. Car." The reverse of this label, a bit of white card, evidently clipped from a larger piece, shows parts of several letters written in lead pencil, and possibly in Agassiz's hand, that may easily be construed to have spelled the word "*Gibbesii*." Apparently the original label was cut down, and the later identification as *Squalodon* added by another hand, as yet unrecognized. Aside from this there is no direct evidence that the specimen is Agassiz's type. His description, however, indicates: (1) that the tooth was imperfect, yet with sufficient crown and root to show their character; (2) that the crown was flattened or compressed, with acute serrated edge; (3) that it was an anterior tooth. These requirements the specimen



SAUROCETUS GIBBESII AGASSIZ

Fig. 1. Side view of the type tooth. Natural size.
Fig. 2. Same, from in front, the labial side above. Natural size.

completely fulfils. Its crown is nearly complete, and measures 35 mm. from the tip to the front edge, 22.5 mm. from front to back of crown. In form it is compressed, with some half dozen or more minute and blunt serrations on the sharp anterior edge, and apparently with a few similar ones near the base of the posterior edge, where, however, it is slightly broken. The outer side is slightly convex, the inner correspondingly concave. The enamel is marked with low ridges running from base to summit. The tooth was probably from an anterior position in the left lower jaw. Only the upper part of the root remains with, however, a considerable vertical groove medially, extending two-thirds the height of the crown on the inner side (Fig. 1). There is only a slight groove on the outer side, so that a cross-section would have nearly the shape of a figure 8, hence the tooth must have been an anterior premolar. The entire specimen is stained a blackish brown.

It is obvious that this represents a large squalodont rather than a zeuglodont, and it is presumably from the Ashley River phosphate deposits. Mr. Remington Kellogg, who has lately studied material from this locality, tells me that it is not to be identified with the large *Squalodon tiedemani* J. A. Allen. He thinks it possibly the same as *Colophonodon holmesii* of Leidy based on isolated teeth from the Ashley River, over which it would have priority, but owing to the fragmentary nature of the remains this identity is not yet certain (see Kellogg, Proc. U. S. Nat. Mus., vol. 62, art. 16, p. 15, 1923). Its age is presumably Miocene.

These facts regarding the specimen are placed on record in the hope that they may be useful should additional material become available for a more exact determination.

Cambridge, Mass.

SOME FURTHER OBSERVATIONS ON THE CHIMPANZEE

By W. Henry Sheak

The mind and manners of mammals are as legitimate a field of scientific investigation as the brain through which that mind functions or the brain case enclosing and protecting this central mass of nervous matter. The disposition and intelligence of the ape fall within the scope of the naturalist just as truly as do the organs of digestion and the bony framework. Indeed, if evolution have a purpose and all the change and advance between the amœba and man be not wholly the result of blind chance, then the mind and the morals of animals must be the ultimate goal of nature and the one supreme reason for the development of physical organism.

The behavior of any animal under changed environment, such as the conditions of captivity, furnishes a most valuable key to the mental capacity of that species. Hence these notes. In the Proceedings of the Indiana Academy of Science for 1917, I published a paper on the disposition and intelligence of the chimpanzee. The present paper is supplementary to that one and is transcribed from notes made during the five years—1907 to 1912—I was connected with the Edwards Animal Show.

The adult chimpanzee is almost always savage and vindictive, but the young are gentle, docile, and affectionate. The mental capacity is high. There is, however, a great difference between individuals, just as there is between humans.

At one time we were moving our animals from Philadelphia to Rochester. Business made it necessary for me to remain behind and for about two weeks our chimpanzee, Joe, did not see me. He was about two and a half years old and had been received into the menagerie about ten weeks before this time. At first he had shown a violent dislike to me. Toward the other members of the company he was friendly, but when I approached he would scream with anger and threaten to bite. Mr. Edwards suggested that I must look like the man who shot his mother. I did not press myself upon him, but let him overcome his aversion in his own way. Very soon his antipathy began to weaken and we became the best of friends. I had never fed him nor in any way looked after his material comfort. His affection for me was altogether unselfish.

When I entered the room at Rochester the chimpanzee was fast asleep in a chair on the stage. I approached and spoke to him, but

he was too sound asleep to hear. I then shook him and said, "Joe, you don't know who is here." His eyes came open and he stared at me blankly for half a minute in a dull stupid sort of way, after the manner of a man suddenly awakened, as if he could not realize who was before him; then recognition began to dawn in his eyes, he gave one bark of delight, jumped from the chair, threw his arms about my neck, and hugged me frantically, but tenderly. He clung to me for fully ten minutes. He seemed to revel in the pleasure of my presence and every time I came near him that day he would put his arms about me and hug me.

Joe got into the habit of climbing down from the stage and running away. In his earlier years of captivity he was seldom kept in a cage. One day in Philadelphia the manager brought in a whip and said that when I caught Joe down on the floor, I should take the whip and give him a cut. It was not long until I caught him running away again. I took the whip and went after him, but he ran and climbed back on the stage, so that I did not get near enough to him while on the floor to hit him. As soon as he was back on the stage, he put out his arms to hug me and commenced his low cooing, coaxing note. He knew that if he hugged me, I could not whip him.

In Rochester we received a large chimpanzee which we named Mike. He was about five years old. When the shipping box was opened and he came out into the room, he was afraid. The entire environment was new to him and every object that met his eyes seemed to portend evil. He was ready to fight, but only because he was afraid—afraid he was going to be hurt. We spoke kindly and soothingly to him and induced him to go into a cage. But within three hours of his arrival, we set him at liberty on the stage and he was at liberty for months. He gave the keepers various bites and knocks, but, on the whole, he was very well behaved.

I once had to do with a treacherous specimen. This was a female about four years old. On more than one occasion, when some friend was playing with her, someone she knew, and she seemed to be in the best of humor, did she turn on him and bite him. One morning, immediately after the doors were opened to the public, she was still sleeping in her cage, when some visitors wanted to see her get up. I spoke to her gently, took a grape between my thumb and finger, and held it toward her. She came over slowly. I thought she was going to take the grape with her fingers, but as she came near she put out her long lips. I had often let her take food from my hand. But she made

a sudden dash, caught my thumb and forefinger between her teeth, and gave me a painful bite. There had been no provocation whatever.

The chimpanzee is affectionate toward members of his own species and toward other animals, especially his nearest relatives, the simians. One morning Joe was teasing Jerry, a baby chimpanzee about eighteen months old. Jerry, who had a temper of his own, got angry and commenced screaming. Mike came running, grabbed Jerry into his arms, and ran away with him.

When Jerry was sick with a cold and I was trying to do something for him, Mike took my hand and gently drew it away from the little fellow. His conduct said as plainly as words could have said, "I do not want to hurt you, but please to let him alone when he is sick."

Sallie was about four years old. Another female about two years old was added to the menagerie. We called her Josephine. When the youngster was first put into the cage with Sallie, the latter was much delighted. She screamed with pleasure, threw her arms about the baby, and hugged her vigorously. In New York a young orang-utan came to live with us. Sallie seemed to realize that he was a close relative, screamed with delight, gathered him in her arms, and hugged and kissed him. Sallie liked a little Marguerite capuchin, too, and would tickle him about the breast and play with him, much as a human child plays with a pet kitten. She was also fond of some spider monkeys and would go visiting in their cage, often for an hour at a time. Joe did not like the spider monkeys and would pull their tails at every opportunity, but he was very fond of a young mandrill. He would take the keenest delight in her presence, permitting her to pull him around, chew his ears, climb all over him, and stand on his head. Both Joe and Mike used to derive much pleasure from backing up against a cage containing a mother and baby macaque, and permitting the youngster to pull and scratch at them. But when the mother made a charge, they scampered away.

But the chimpanzee, with all his affection, not to say love, is an inveterate tease and torment. His best friends are not exempt from his pranks. I have related how pleased Sallie was to see baby Josephine. But she soon took to frightening her and bit her in the hand. After they were separated, she would come to the end of her cage next to the baby, jump against the wires, kick the floor, and scream, just to see the baby's terror. She once got hold of a long stick, poked it between the wires of the next cage, and tried to stir up the baby chimpanzee. On another day she tried to poke a big Anubis baboon in an

adjoining cage with a long whip, then got the whip through between the front wires and tried to hit the people before the stage. Mike liked to tickle Baby Jerry. Sometimes he would put his hand under Jerry's sweater coat and tickle him about the breast and shoulders till the little fellow would laugh aloud.

It made Sallie very angry to laugh at her when she was in trouble. Like Joe, she got into the habit of getting off the platform and running away. When we went after her she would run under the stage and dodge about among the boxes and barrels usually kept there, leading us a merry chase. When we got her finally, our patience had usually reached the tearing point; consequently, the cage door was opened and Miss Sallie thrown in summarily and often with much force. Then the spectators would laugh at her discomfiture. This threw her into a violent passion. She would jump up and down, kick the floor, scream, then pull the door up as far as it would come, till she could get her hand out under it, and work her fingers violently as if to say, "You see what I would like to do to you!"

Playfulness is one of the characteristic traits of the chimpanzee. He is of a nervous, active temperament, always at some prank, always inventing some new way of amusing himself, always trying to imitate his human companions. Joe and Mike liked to chase each other around a chair. Sometimes each would take hold of the same upright bar or post with the left hand and chase each other round and round, each running as fast as he could go. Joe would pull a man's cap down over his eyes and then go feeling about the stage. Sometimes he would seem to be hunting for Kongo, the negro who occupied the platform with him, or for me. He would come toward me with his arms out, feeling, and when he touched me would take hold and try to pull himself up or try to pull my hand into his mouth, all the time with the cap over his eyes. Once he bumped hard against a chair and once against a post. Mike would often put a blanket over his head and play hide-and-go-seek with Joe. Once he walked off the stage and fell to the floor, but he had scarcely lit till he was back in his place again. Thus they would romp for hours.

One of Joe's favorite amusements was to put his hand on my shoulder and push on me till I walked with him to the other end of the stage, I on the floor, he on the stage. Then he would turn around and push the other way and we would walk back. In this way he would take me back and forth for several trips. Jumping was another of Joe's favorite sports. I have seen him stand on one chair and jump to

another three feet away, without any assistance from his hands. He would sometimes stand on a chair, take me by the hand, and jump to the floor. He had the habit of catching hold of my pointer with one or both hands and swinging on it. One day I was not holding the stick firmly and when he grabbed it it came out of my hand. Immediately he turned and handed it back to me. Another time in playing about the stage he upset a chair. At once he turned and picked it up. Baby Jerry was cutting teeth and we bought him a rattle box with a rubber ring attached. The rattles were in the form of sleigh bells. Joe tore one of these bells loose and amused himself with it for two weeks. He would put it in his mouth, then shake his head to hear it rattle. When given two nickels he put them in his mouth and held them loosely, so that when he shook his head they rattled against his teeth. One day he put a peanut in his mouth and shook his head, thinking it would rattle.

Our chimpanzees often had toys given them and frequently had a considerable collection. Joe now and then insisted on playing with his toys while I was lecturing. He often ran away, when someone had to go after him, but if he dropped a toy, he would get down, even on the floor of the room, recover the plaything, and then come back of his own accord and resume his seat on the chair. The chimpanzee unquestionably recognizes youth in other animals and in human children. In the city of Omaha we had a children's day, when about ninety-five per cent of our patrons were children under twelve years of age. Joe was in an ecstasy of delight. I could hardly keep him on the stage. He wanted to get right down among the children.

Keeper Russell taught Joe to give a tooth-pulling exhibition. With a pair of plyers he would take hold of one of the ape's teeth and work and work, as if making a great effort to extract the molar. Joe would open his mouth, turn his head to one side, and enter into the performance with much earnestness. Then he would turn the other side of his face. One day when Russell was not present he got the plyers and tried to pull his tooth himself, first on one side, then on the other. When in some mischief, Russell would take him by the ear and lead him across the stage. One day Mike took Joe by the ear and led him in the same way.

The leopard is the most dreaded enemy of this ape. Not long after Sallie came into captivity, I had her sitting in a chair one morning when a leopard commenced his characteristic "wood-sawing." The chimpanzee jumped to the floor, ran to the cage, lifted up the door,

hurried in, and closed the door behind her. She recognized the fact that the cage was as good a contrivance to keep enemies out as to keep her in.

Jealousy and selfishness are as well developed in the chimpanzee as in the human. At one lecture I shook hands with Mike, then with Joe, first with his right hand, then with his right foot. No sooner had I done this than Mike took hold of my hand and put his right foot up to me. This may not have been so much a case of jealousy as a mere desire to have me do with him just as I had done with Joe. One evening when I was lecturing, Joe was busy swinging on the bars and would not come when I wanted to show his hand, but Mike came and put out his hand for me. I took it and proceeded with the talk. Then Joe at once came down and put out his hand. When I did not take it, he put it up into my face. This was a plain case of jealousy. I was in the habit of giving the exhibition with Joe, not with Mike. Joe did not want his companion to usurp his place. Sallie would run the capuchin and spider monkeys away when she saw one of us petting them.

In New York, when given two oranges, Sallie proffered me one. I took it, but in a moment handed it back to her. She received the fruit, but almost immediately offered it to me again. This time I put it in my pocket, when she seemed to be satisfied. Just how much of disinterested generosity there was in this act, I have never been able to decide.

In all his actions and attitudes the chimpanzee is very human-like. Most chimpanzees are decidedly right-handed, but Joe was left-handed. Young chimpanzees, from two to five years of age, are very active and playful from morning till about the middle of the afternoon, when they become tired and sleepy, and take a siesta or afternoon nap, much like human children of similar age. Both Mike and Joe have exhibited marked cases of hiccoughs. Mike sat one day with his right elbow resting on his knee and his chin on his hand. When Sallie grew tired and sleepy at night, she would insist on the keeper carrying her up and down the room in his arms. If he put her down there was trouble. Baby Jerry got into the same habit. He would scream and pound on the floor with his hands when the keeper refused to take him.

The senior Mr. Edwards had Sallie very much spoiled. She was much attached to him and he would let her do just about as she pleased. She was fairly obedient when he was not in sight, but as soon as he

came near she would run to his arms and no one else had the least influence over her. One evening Joe got down off the stage. I started after him, but he ran to Joseph Edwards, then turned and barked defiance at me from his master's arms. One day Sallie, in the absence of the keeper, attempted to run away and when a man who was at work in the room stopped her, she became very angry and threatened him, then ran to me, put her hand on my shoulder and barked in my ear, as if trying to tell me about it and enlist my sympathy.

When I first came to the menagerie Sallie lacerated her finger one morning on a piece of wire on the cage door. It was evidently painful, for she kept looking at the wound every now and then, and when the senior Mr. Edwards arrived she showed him the place.

"Oh, let me kiss it," he said in very sympathetic tones.

After that, so long as it was sore, she would put up her hand for him to kiss it whenever he came near her.

When Sallie was given a pan of bread and milk, she ate the bread that was in the milk, then took the dry bread that was remaining and soaked each piece separately in the milk before eating it. Once Mr. Edwards brought in a dipper of malted milk, warm from the stove. He poured out a cupful for Joe. He then poured a second cupful, set the dipper down, and went to the other end of the stage to give Mike his share. Before he got back Joe had drained his cup. He did not want to be helped, but took up the dipper and poured his cup about half full, without spilling a drop.

This ape is highly imitative. One morning the keeper had left some sawdust on the stage. Joe got the short-handled broom and the dust pan and tried to sweep the sawdust on the pan, just as he had seen the keeper do. He did it fairly well, too. Joe was once having a romp with the young mandrill when I wanted him for the exhibition. I took him from the cage, but forgot to fasten the door with the snap. This snap was the same as those used on the harness of horses. He noticed my delinquency, went back to the cage, and put on the snap himself. A little later he tried to take off the snap to get back into the cage, but in this he was not successful. On the same stage with the chimpanzees we had a negro known as Kongo. He wore a leopard skin about his loins. Several times, in Kongo's absence, Joe ensconced himself in the negro's chair beside a table, and took a leopard skin which was on exhibition nearby and tried to fold it about his loins.

One of the most surprising exhibitions of intelligence ever staged by an animal below man, was shown by the chimpanzee Joe in connection with this negro, Kongo. I have already spoken of Joe's habit of running away and the whip the manager bought for me to use in bringing him back. It was not often I touched him with the whip. Generally whipping the floor near him was sufficient. Kongo had the mind of a child of six or eight years. In Kansas City we had in our exhibition room, which was a big old church, a large orchestrion, operated by electricity. When I was ready to begin a lecture on the animals, I would have to go to the front of the room and turn off the electric current. Kongo, child-like, found much pleasure in doing this for me. One afternoon he and Joe were both out of their places and down on the floor walking around among the few visitors we had at the time. When Kongo saw me start toward the electric button, he said,

"Oh, let me, let me," and started toward the front of the room on a dog trot.

Evidently Joe thought Kongo was running away, just as he himself often did. He seized the long whip and started after the negro. When he got near him he began whipping the floor. He did not once touch the man with the weapon, but kept thrashing the floor near his feet, until the supposed runaway was back again on the stage.

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GENERAL NOTES

CINNAMON AND ALBINO OPOSSUMS FOUND AT AUSTIN, TEXAS

In the August, 1922, number of this Journal, Prof. Carl Hartman reported a brown or "cinnamon" mutation in the Virginia opossum. This mutant together with two albinos was figured in the Journal of Heredity, December, 1922, pp. 472 and 473. Doctor Hartman's cinnamon specimens came from Missouri, the albinos from Oklahoma.

The present writer has since secured a cinnamon female and an albino male on Shoal Creek, within the city limits of Austin, Texas. Both were large old adults. The cinnamon colored animal answered to the description of those shown in *G* and *I* of Doctor Hartman's figure 19; that is, it had white over-hair, the pigmented region of the body all being brown. The white opossum was exactly like those figured in *A* and *B* in Doctor Hartman's figure 18; the animal was not a true albino, having black pigment in ears, iris of eyes, skin of feet, and base of tail; we might term it "albinoid."

I wish further to record a black female and her progeny of eight young. The mother had black over-hair like *C* and *D* of figure 18 (Hartman, *l. c.*). Five of the pouch-young were gray (like *E* and *F* of figure 18), while three were black like the mother. Since the ratio of grays to blacks at Austin, Texas, runs ten to one, the chances are ten to one that the sire of the above mentioned pouch-young was gray.

Only a few days after the cinnamon individual under discussion was found, another was reported to me from the same locality.

Without stating as a positive explanation the genetics of the mutations considered, a probable explanation of the conditions described is given. The following tentative genetic explanation is suggested:

There is at least one pair of allelomorphs distinguishing black from brown pigment in the hair, provided pigment is present. In addition to this "black-versus-brown" pair of distinguishing allelomorphs, there may be another pair determining whether pigment shall be present in the over-hair. Finally, the albinoid is probably a result of the action of a pair of allelomorphs, one factor of which produces pigment, while the other produces a complete lack of pigmentation in the hair.

I desire also to take this occasion to report a change of color from gray to brown in opossums after death. For, while botanizing, I once came upon the carcasses of five opossums which had been stripped of their hides by a trapper. In skinning an opossum a ring of fur from one to two inches wide is left around each leg near the foot, another ring around the base of the tail. The hair on these rings all appeared cinnamon color. It was thought strange that so large a number of cinnamon opossums should have been captured at one time and place. Upon investigating and experimenting, however, it was found that gray opossum hair when left exposed to the weather turns to a cinnamon color not readily distinguishable from the color of the live cinnamon animal. I am also told that some of the opposum skins stored in museums have changed toward the brown color; I have in mind, for example, the opossum group in the exposition hall of the National Museum, the individuals of which group now possess a distinctly brown hue. This change of color is of interest in connection with Sewell Wright's enzyme theory of pigmentation.—W. KENNETH CUYLER, *The University of Texas, Austin, Tex.*

ON THE NAMES OF TWO GENERA OF INSECTIVORA

The preparation of a new volume of my "Genera Mammalium" has compelled me to revise the nomenclature of the Insectivora, and, in doing so, I have found that the name *Pachyura*, generally used for a genus of white-toothed shrews, is unfortunately antedated by *Suncus*. De Sélys-Longchamps proposed *Pachyura* in 1839 (Études de Micromammalogie, p. 32) for a subgenus of *Crocidura*, based on *Sorex etruscus* Savi, but this group is treated today as a full genus. *Suncus* was established in 1832 by Hemprich and Ehrenberg (Symbolæ Physicæ, II, k) the genotype being *Suncus sacer*, = *Sorex crassicaudus* Lichtenstein. Both genotypes being universally treated as congeneric species, we are forced to use the oldest generic name.

Suncus has been frequently considered as a synonym of the restricted genus *Crocidura*, and in Trouessart's "Catalogue" *Suncus sacer* is put among the synonyms of *Crocidura religiosa* Geoffroy, but there is no ground for such view, as Hemprich and Ehrenberg clearly state that the type of *Suncus* was the actual shrew sent by them to Berlin under the handwritten name *Sorex crassicaudus* and described afterwards with the same name by Lichtenstein. It is true that in the description of *Suncus* the upper unicuspid teeth are said to be three, whereas four is the characteristic number in *Pachyura*, but from the dental formula given by these German naturalists it clearly appears that some teeth (probably the little fourth unicuspid and the last molar) were overlooked by them, as they mention only three molariform teeth after the unicuspid series, the true number being constantly four in all the shrews. Such mistakes are quite easy when examining specimens in the flesh, or even preserved in alcohol, and we have another instance in the original diagnosis of *Myosorex* by Gray, in which only two lower unicuspids are assigned to this genus, thus missing its chief distinctive character. Errors in description do not justify the rejecting of a generic name when a recognizable genotype is designated. In the present case, there is no doubt that the authors founded the genus on the big Egyptian shrew, which belongs to the group generally named *Pachyura*, and as *Suncus* antedates this name, it must be used, with *Suncus crassicaudus* as genotype.

Gymnura, as the name of a genus of the Erinaceidæ, must also be replaced, it being invalidated by the use of the same name in ichthyology. The genus *Gymnura* in mammals was founded by Lesson in 1827 (Manuel de Mammalogie, p. 171) for *Viverra gymnura* Raffles, but three years before, in an extract from a letter to Temminck on the fishes of Java, published in Férussac's "Bulletin des Sciences naturalles et de Géologie" (vol. 2, 1824, p. 90), the Dutch naturalist Van Hasselt says as follows: "Un poisson singulier est le *Raja micrura* Schn., fig. par Russ., Pl. 6, et dont Kuhl, suivant ses manuscrits, a fait un genre particulier sous le nom de *Gymnura*." There is on the same page a footnote telling us Valenciennes rejected this name on the ground that "ce nom générique ne conviendrait point á ces poissons parce qu'il paraît que les aiguillons de la queue des individus de nos cabinets ont été arrachés par les pêcheurs."

Although published without any description, *Gymnura* is perfectly tenable in this sense, a previously known species being designated as genotype, and, as clearly stated by Van Hasselt himself, we must consider Kuhl as the author of the genus. Rejected by Valenciennes, because of inappropriateness, just at the moment of being published, the name became, as it appears, totally forgotten.

I have not seen it in any general work on fishes, nor even in Gunther's exhaustive "Catalogue," and it would be well to tell our friends the ichthyologists that *Gymnura* Kuhl (1824) antedates *Pteroplatea* Müll. and H. (1827). From our point of view, the unexpected result is the invalidation of *Gymnura* in mammals. Fortunately, it is not necessary to invent a new name to replace it, as we have an available one in *Echinosorex* Blainville (Compt.-Rend. Acad. des Sciences, 2d. series, 10, 1838, p. 120). The subfamily name Gymnurinæ, consequently, must be replaced by Echinosoricinæ.—A. Cabrera, *Museo Nacional de Ciencias Naturales, Madrid, Spain.*

SEALS AS SPERM WHALE FOOD

Capt. D. C. Stull, the veteran dealer in ambergris and manufacturer of watch oils, has kindly permitted me to examine and dissect various samples of ambergris in his laboratory at Provincetown, Massachusetts. One small lot of this valuable substance contained, in addition to the usual beaks and optic lenses of cephalopods, a number of small bristles which have been identified beyond doubt as the characteristic, nodulated, facial vibrissæ of a seal. According to the memory of Captain Stull, the ambergris came from a sperm whale taken by a New Bedford whaler on the coast of Haiti, during the year 1912.

The bristles are not appreciably corroded and, as the writer once drew and published the figure of a seal's whisker (Bull. Amer. Mus. Nat. Hist., vol. 33, 1914, p. 76), their nature was recognized even before they had been extracted from the substance of the ambergris.

A hasty survey of the literature reveals no record of sperm whales feeding upon other mammals, but the evidence of seal bristles in a whale's digestive tract is highly circumstantial. We may accept as indubitable that the ambergris came from the entrails of nothing other than *Physeter*, even though Captain Stull lacks written memoranda of the identity, locality, and date. Haiti is on the border of the former range of the West Indian seal (*Monachus tropicalis*), but it is not unlikely that the sperm whale's victim was devoured in quite other seas; the bristles may, indeed, have been imbedded in their intestinal matrix for years. A comparison of the specimens with the vibrissæ of various pinnipeds does not justify an attempt at specific determination. It is safe to say, however, that they pertain to some kind of phocid seal.—Robert Cushman Murphy, *American Museum of Natural History, New York.*

ANOTHER FOSSIL CARIBOU FROM NEW YORK STATE

Having recently examined a copy of Hartnagel and Bishop's "Mastodons, Mammoths and Other Pleistocene Mammals, Being a Descriptive Record of all Known Occurrences,"[1] we note with interest the citation of remains of but two fossil caribou. We believe therefore that the following occurrence should be placed on record.

In the collections of the Portland Society of Natural History, at Portland, Maine, is a horn of a caribou, rather recently presented, together with other objects, by daughters of the late Maj. Charles Harrod Boyd. The specimen bears these data: "Caribou horn from swamp 6 feet below surface—E. Bartlett—Rockwood—Fairytown—N—Y—1853."

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[1] N. Y. State Mus. Bull. no. 241-242. 1922.

The antler, which is from the right side of the head, is attached to the parietal bone, and bears but one branch, which leaves the main shaft 4½ inches above the burr. Both the main shaft and the branch have their tips broken off. The chord of the main shaft from the burr measures 23½ inches, and has a diameter of 1¼ inches just above the branch; the branch measured from the front of the main shaft along its lower surface has a length of 8 inches, and is nearly uniform in diameter for its entire remaining length.—ARTHUR H. NORTON, *Museum of Natural History, Portland, Maine.*

THE PYGMY OR GABOON BUFFALO

The pygmy buffalo, a stout and pugnacious beast of the Gaboon country in French Congo, is a very interesting animal. As is true of most bovines, it seems to know no fear. I have hunted this animal, which lives in the land of the gorilla, and on several occasions have enjoyed the excitement of a charge; the habit of the buffalo seems to be "to battle to the death."

While walking on the plain near camp with my guide I saw quite a herd of "nyari" (as called by the natives) grazing not far off. Carefully maneuvering for a shot I selected one I thought was a fine male. I shot at a distance of about 75 yards and hit it a trifle high in the neck. In fact the bullet merely creased the skin. It fell like a flounder, but immediately got up and I shot it again when it entered some tall grass. We went in after it, and, on emerging onto the open plain, found the buffalo waiting for us. It instantly charged and but for the boy would have gotten me as I had used the last cartridge in my gun. The native boy had a 30-30 Winchester, but before using it he ran between me and the beast and diverted its attention from me. He kept running for about 100 feet and the buffalo was about to toss him, having its head down, when he turned suddenly and the beast, in trying to turn with him, fell down not to rise again as he then put a "finisher" in it. It turned out to be a fine female specimen apparently with a sucking calf.

Natives of the Gaboon hold the buffalo in the greatest of awe, and if a "checking up" were made many victims could be found to its credit. The buffalo is usually found in the forest during the heat of the day, but on several occasions I ran into some lying in tall grass on the plain during the middle of the day. These stocky animals are quite crafty, especially when resting. While they possess a very keen eyesight as well as a highly developed sense of smell, they always have two or three doing guard duty (I found this true also of the red riverhog), and when these become tired others take their places.

The different color phases of the buffalo were quite noticeable. The younger ones were of a tawny color, but with age they get quite dark, looking as though black from a distance. They averaged around 50 inches high at shoulders, but one female (very old) measured at least two inches more.

On one occasion some boys were bringing a canoe from another town to me, and ran across a buffalo in the middle of Lake Ngovi, which is at least two miles from bank to bank. They dispatched the beast with an ax and machetes.—C. R. ASCHEMEIER, *National Museum, Washington, D. C.*

COUES PORCUPINE IN COLORADO

Among the porcupines from Colorado in the mammal collection of the Colorado Museum of Natural History, is a specimen of *Erethizon epixanthum couesi*. This specimen is the first recorded for the state, and is from a locality which materially extends the known range of the species.

The specimen in question, an adult female, No. 931, Colorado Museum of Natural History was taken in the yellow pine belt of the Transition Zone, near Chromo, Archuleta County, Colorado, at an altitude of about 8,500 feet, on July 10, 1913.

Measurements of the specimen are as follows: Total length, 658; hind-foot, 196; tail vertebræ, 84; skull, basilar length, 83; zygomatic breadth, 67; mastoid breadth, 43; interorbital constriction, 33; length of the molar series, 26.2. The auditory bullæ are characteristically greatly inflated and measure 21 by 15.—FREDERIC W. MILLER, *Colorado Museum of Natural History, Denver, Colo.*

SWIMMING RED SQUIRRELS

Notes on the aquatic habits of woodchucks in the Journal for November reminded me of similar observations on red squirrels. When canoeing on the West Branch of the Penobscot River, Maine, in September, 1913, with Doctor Copeland and Doctor Gross of Bowdoin College, I saw some small animal swimming across the river, which at that point is about 50 yards wide and quite swift. Supposing the animal to be a mink we gave chase but found to our surprise it was a red squirrel. On our close approach he swam toward us and tried to climb up the side of the canoe. When offered a paddle he promptly ran up the handle but when we tried to catch him he ran the length of the canoe and again took to the water. After this he swam with difficulty but reached the opposite shore where we left him resting on some drift wood.

On the same trip, when running with the current on Umbazooksus Stream, we came suddenly around a bend in full view of a red fox swimming across the middle of a wide pool. He swam very high out of water and his tail floated lightly on the surface. Apparently unconscious of our presence he swam quickly across, ran up on the shore, shook himself, and trotted into the woods. The stream at that point was about 50 feet wide.

On August 2, 1921, when nearing the head of Attean Lake, Maine, with Prof. G. C. Whipple of Harvard I came across another red squirrel swimming. Where we found him the lake is between a quarter and a third of a mile wide and he was then over half way across. At the rate he was swimming I should say it would have taken him 15 to 20 minutes to make the crossing. After photographing him we took him into the canoe on a paddle. He seemed chilled and very tired and after a moment settled down on my knee and sat there while we paddled ashore. That he entered the water voluntarily seems probable from the fact that he was attempting so wide a crossing rather than trying to return to the same shore.—ALTON S. POPE, *Brookline, Mass.*

DEATH OF H. A. P. SMITH

In the death of Henry Albert Pattinson Smith, sheriff of Digby County, Nova Scotia, which took place at St. John, New Brunswick, on the 29th April, 1923, the cause of game conservation lost a valuable friend. An ardent sportsman and hunter, Mr. Smith was for many years identified with the study of our wild life, and during his career was responsible for many interesting observations of scientific value.

Mr. Smith was born in Halifax, April 24, 1864, the son of an English physician, Dr. Peleg Wiswall Smith. He was appointed sheriff of Digby County in 1897 and in 1919 became in addition a deputy warden, with authority to the Maritime Provinces, under the Migratory Birds Convention Act. In the interests of this work he was visiting New Brunswick when he was stricken with what proved to be his last illness.

He was a member of the Ottawa Field Naturalists' Club and the American Society of Mammalogists, and an Associate of the American Ornithologists' Union. He spent the summer of 1920 in the Canadian Labrador where he did splendid work in the protection of the breeding colonies of sea birds which are found on those shores.

His articles dealing with natural history subjects were of especial interest, portraying as they did many of the hitherto little known habits of birds and mammals. Many of these articles were of unique value, reflecting conditions of wild life in Nova Scotia which no longer exist and were based upon his observations during many years in the open.

He played a prominent part in the introduction of the white-tailed deer into Nova Scotia, assisting personally in rounding up a considerable number in New Brunswick, in the deep snows of winter, for importation to this Province.

In the late nineties Mr. Smith rendered valuable assistance to Mr. Outram Bangs, now associated with the Museum of Comparative Zoology at Harvard University, in the accumulation of a collection of mammals of Nova Scotia and on October 15th, 1898, he secured for this scientist three specimens of the caribou believed to be now extirpated in this province except in Cape Breton.

He contributed articles to the Canadian Field Naturalist, the Journal of Mammalogy, and to Forest and Stream and other sporting papers.—R. W. Tufts, *Wolfville, Nova Scotia.*

RECENT LITERATURE

Fox, Herbert. Disease in Captive Wild Mammals and Birds. Incidence, Description, Comparison. With a foreword by Charles B. Penrose, M.D., President of the Zoological Society of Philadelphia. Zoological Society of Philadelphia (seal). Philadelphia, London, and Chicago: J. B. Lippincott Company. 8vo. 665 + vii pp., 87 figs. $12. 1923.

This volume contains an account of the observations from nearly 6000 autopsies upon mammals and birds made at the Philadelphia Zoological Garden during the last twenty years by Doctor Fox and his associates, Dr. E. P. Corson-White and Dr. F. D. Weidman. The writers have combined a knowledge of a scattered literature and their own rich experience into a volume, the first of its kind to cover systematically the subject of the diseases of wild animals. The book contains chapters on special pathological anatomy, on constitutional diseases, on the relation of diet to disease, on neoplasms, on infectious diseases, and on animal parasites. Instead of giving only the details of individual autopsies, the authors have attempted to correlate their findings in the different groups of captive wild life with the existing knowledge of the pathology of man and domesticated animals. The result is a book containing many interesting comparative data and many stimulating discussions. An introductory chapter by Charles B. Penrose exhibits a discerning and sympathetic insight into the mental behavior and welfare of the captive wild animal.

The book is invaluable to those who concern themselves with the care of zoological gardens. There are observations upon practical hygiene, preventive medicine, and dietetics in relation to the preservation of wild animals in captivity. The purely scientific workers in the fields of pathology, bacteriology, parasitology, comparative anatomy and physiology will find much that interests them.

One becomes acquainted with the wide range of pathological changes in captive wild animals. As regards some diseases, particularly parasitic ones, additional evidence is cited to show that animals are subject to them in their wild state also. The table of neoplastic growths indicates their diverse character and frequency throughout the Aves and mammals. One learns that thyroid disease, though present in many orders of mammals, preponderates by far in the Carnivora. Pancreatitis occurs among animals, also most frequently in Carnivora. Among 585 animals in which the pancreatic duct opened independently of the bile duct into the duodenum, eight showed pancreatitis. From a large material these investigators have demonstrated that mammals are much more susceptible than birds to degenerative and inflammatory processes of the heart. The former also show an ability to increase the muscle bulk two and a half times as great, and are liable to chamber distension nearly ten times as often.

The sections on constitutional diseases and on the diseases of blood forming tissues and of the central nervous system are not as valuable as others. One must remember, however, the years and years of painstaking research which have brought these chapters in the human even to their as yet incomplete state. Furthermore, our knowledge of these diseases in man has been advanced to a large extent by the opportunity for careful clinical observation aided by all the modern methods of hematology, neurological examination and biological chemistry. The Philadelphia workers are aware of the limitations in clinical diagnosis on wild animals and the unavoidable shortcomings this restriction entails.

Finally, we would like to say a few words about the use for scientific purposes of material from zoological gardens. Two groups of scientists, the pathologists and the comparative anatomists, are in a position to advance our knowledge the most by its use. With many of the rarer animals it would seem advisable for the pathologist to cooperate and to consult with his anatomist associates as to the most profitable use of the material in the advancement of science. The Philadelphia workers have shown a broad scientific spirit in collecting the intact brains of the animals which they have autopsied. Of all the soft parts, however, the brain is the only organ frequently preserved, a number of fine collections existing in America and abroad. But on the other hand the remaining soft parts, although equally important, have been sadly neglected by collectors for museums and sportsmen on whom the anatomist must rely for his material. Nevertheless the comparative anatomist is interested equally in all soft parts, such as for instance: muscles, their innervation, origin and insertion; viscera, their relation in the intact animal to one another; the vascular system; the lymphatic system; the sympathetic nervous system, etc. For their study a few of these require painstaking dissections on intact material; by cooperative efforts the pathologist and anatomist can both attain their ends without interference with the needs of the other. And with such joint studies the anatomist will be able to advance knowledge of the normal anatomy of the species, without which the pathologist is necessarily at a great disadvantage.

Doctor Fox has shown by the present volume, as well as by numerous articles which have been published by himself and by members of his staff, how the autopsy material of a zoological garden can be utilized in the best interests of the garden itself, as well as in the advancement of scientific knowledge. His observations will be of lasting value to many groups of biologists, but particularly to the human pathologist who will have an opportunity to widen his experience by becoming familiar with the closely related field of comparative pathology.

—*George B. Wislocki.*

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CORRESPONDENCE

DAMAGE BY KANGAROO RATS

Editor of the Journal of Mammalogy:

Referring to the review of our paper on the "Life History of the Kangaroo Rat," U. S. Dept. Agric. Bull. no. 1091, 1922, by Joseph Dixon (Journ. Mamm., vol. 4, no. 2, p. 130), we desire to make the following statement by way of correction or emendation of the original publication, with reference to the amount of damage done by kangaroo rats and its possible economic consequences. First, it appears that we were in error as to the amount of dry food a steer needs per day. The amount on which estimates were based was given as 50 pounds per steer per day, whereas we are now assured that 25 pounds would be more nearly correct. This would of itself change the figures so that the text should read (p. 37): "Allowing 25 pounds of food a day for each steer, the forage destroyed would be sufficient to provide for . . . . the needs of 28 [instead of 14] steers for one year."

Second, the reviewer criticizes the succeeding sentence which says "this might easily mean the difference between success and failure." The fault is ours in presenting the data as we did. The effect of the damage is felt in a smaller unit of time than one year. Since southern Arizona is characterized by both summer and winter rainy seasons, conditions are never as critical for the entire year as they often are for a brief period, usually in the arid foresummer (May-June), and the data should have been so prepared as to make this point. The food of 14 steers for one year would be equivalent to the food of 168 steers for one month. Doubling this, in the light of the new figures per steer per day, yields the astonishing result that the forage destroyed annually on the Range Reserve would suffice to support 336 cattle for one month, or 168 cattle for two months. While this material is largely stored during the periods of greatest abundance, when its loss is not felt, it is nevertheless not available during the critical foresummer period when forage is scarce. This critical period is usually short, much better represented by one or two months than by the year.

Since it is seldom practicable to make extensive shifts of stock during dry times, the number of cows which can be supported on a given area depends on the carrying capacity of the area during its driest period. If, as our figures seem to indicate, forage sufficient to support 168 cattle for two months, or 336 cattle for one month, is rendered non-available, it seems clear that, during seasons of drought, the banner-tailed kangaroo rat, where it is abundant on the grazing ranges of the Southwest, may be a factor of critical importance in relation to forage production and carrying capacity. It may be added that 336 represents approximately one-fourth of the cattle carried on the entire Range Reserve of 50 sections of land. We are thus compelled to admit that the possibilities of damage with the revised and more accurate figures appear even more serious than we ourselves had realized.

Charles T. Vorhies.
Walter P. Taylor.